ANATOMY

AND

PHYSIOLOGY

A TEXT-BOOK FOR NURSES

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PREFACE

In presenting this work to the nursing profession the author has endeavored to cover in as clear and untechnical a manner as possible the essentials of anatomy and physiology. No theories have been included, except those which have been definitely accepted by teachers of the subjects. Emphasis has been placed on the description of organs and their functions which are of fundamental importance in the practice work of the nurse.

The questions at the end of each chapter are added as a means of reviewing the subjects.

The glossary has been added with the object of explaining all technical words in the text.

J. F. L.

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ANATOMY AND PHYSIOLOGY

CHAPTER I

INTRODUCTION

THE human body from birth to old age exhibits in the living condition a series of phenomena by which it grows, performs the various and complex movements of which man is capable in the processes of daily life; thinks, and is conscious of the sensations which bring him into relation with his surroundings, and reproduces, permitting a continuation of the species.

A study of the functions of the numerous organs and structures of the body in a state of health, and their associated phenomena of growth, movement, mentality, and reproduction, is termed **human physiology**.

To understand the functions of organs, etc., it is necessary to first understand the construction of the human body of which they are a part. To this branch of science the term **human anatomy** is applied.

THE ANATOMIC ARRANGEMENT OF THE BODY AS A WHOLE

The human body is divided into an **axial portion** consisting of the head, neck, and trunk; and an **appendicular** portion, including the limbs or extremities—arms, legs, etc.

The **axial portion** is subdivided into a posterior or dorsal cavity, and an anterior or ventral cavity.

The **dorsal cavity** is formed by the vertebræ and their arches of bone, and the bones of the skull. If the

dorsal cavity is sectioned in a longitudinal direction it will show, above, the cranial cavity, and below, the spinal cord, the former containing the brain and its membranes, the latter the spinal cord and its membranes.

The **ventral cavity** includes the space within the trunk and in front of the spinal column. Its walls consist of skin, fascia, and muscles reinforced by bony arches, the ribs, and the pelvic bones. The ventral cavity is subdivided by a musculomembranous wall, the diaphragm, into an upper cavity called the **thorax**, and a lower one, the **abdomen.** The former contains the organs of respiration—the lungs and the heart, covered by their membranes, also the great bloodvessels leading from the heart, and the esophagus (gullet), which conveys food from the pharynx to the stomach by passing through the diaphragm. The abdomen contains the remaining portions of the tube (alimentary canal), which receives the food from the esophagus and ends in the lower part of the cavity called the anus; also the organs of secretion—liver, pancreas, spleen, etc.; excretion—kidneys, bladder, etc., and reproduction in the female.

The **appendicular** portion of the body consists of four extremities—two upper and two lower limbs. The upper limbs consist of bones held together by ligaments, and covered with muscles, tendons, fascia, and skin. The lower limbs have the same construction as the upper, but the joints are not so capable of movement. For example, the shoulder and elbow are freely movable, as compared with the hip.

The study of anatomy is divided into the following branches:

Osteology: the anatomy of the bones.
Syndesmology: the anatomy of the joints.
Myology: the anatomy of the muscles.
Angiology: the anatomy of the bloodvessels.
Neurology: the anatomy of the nerves.

Splanchnology: the anatomy of the internal organs—digestion, respiration, etc.

The construction of each organ and portion of the body, and its independent function, as well as the combined actions of several organs entering into the performance of a definite act, as in digestion, etc., are described under the term **physiologic apparatus.**

Digestive apparatus, by means of which food is digested. **Absorptive apparatus,** for the absorption of nourishment into the lymph and blood. **Circulatory apparatus,** for the distribution of blood from the heart to all portions of the body. The **respiratory apparatus,** by means of which oxygen is absorbed into the blood from the air breathed into the lungs, and carbon dioxide and other waste materials are given off from the blood to the atmosphere. **Urinary apparatus,** for the elimination of waste materials from the body through the kidneys and bladder, as urine. **Secretory** and **perspiratory apparatuses**—the former secreting essential materials for the maintenance of body nutrition; the latter aiding in regulating heat dissipation and in eliminating waste materials through the sweat glands of the skin.

QUESTIONS

1. What do you understand by the term human physiology? Human anatomy?
2. Name the two portions the body is divided into.
3. Give the parts of the body included under the axial and appendicular portions.
4. Name the cavities included in the subdivision of the axial portion.
5. Describe the dorsal cavity. Ventral cavity.
6. What are the subdivisions of the dorsal cavity and contents?
7. What are the subdivisions of the ventral cavity?
8. Name the structure which subdivides the abdomen and thorax.
9. What are the principal organs, etc., contained in the thorax? Abdomen?
10. How many extremities or limbs are included under the appendicular portion of the body?
11. What do you understand by the following terms: Osteology, syndesmology, myology, angiology, neurology, splanchnology?
12. What do you understand by the term physiologic apparatus?

CHAPTER II

CHEMIC COMPOSITION OF THE HUMAN BODY

The human body after a chemic analysis can be reduced into its final constituents. The analysis of the dead body is completed with little difficulty, while the analysis of the constituents of the living body is a most complicated and arduous task. The former procedure is called—**chemic anatomy,** while the latter is termed **chemic physiology.**

The analysis of the human body will disclose the fact that it contains liquid and solid compounds which belong to both the organic and inorganic chemic and plant world. These compounds derived from a proximate analysis are termed **proximate principles.** However, to deserve this term they must be obtained in the form in which they exist in the living body.

The **organic** compounds consist of carbohydrates, fatty and protein groups of organic bodies; the **inorganic** compounds consist of water, various acids, and inorganic salts.

Chemic Elements Found in the Human Body: Oxygen, 72 per cent.; hydrogen, 9.1; nitrogen, 2.5; carbon, 13.5; phosphorus, 1.15; calcium, 1.3; sulphur, 0.147; sodium, 0.1; potassium, 0.026; chlorin, 0.085; fluorin, iron, silicon, magnesium, iodine, in small amounts.

ORGANIC COMPOUNDS

The Carbohydrates.—The carbohydrates are represented in the human body mostly as starches and sugars. They contain carbon, hydrogen, and oxygen,

but no nitrogen — the hydrogen and oxygen being in such proportion as to form water, or as 2 to 1, as is shown in the chemic formula for starch, $C_6H_{10}O_5$.

Few of the carbohydrates are found in the human body, but are found mostly in the foods we eat. They are the most beneficial nourishment for the maintenance of heat and energy, and are, besides, available and easy of digestion.

The carbohydrates are divided into three groups: (1) **Amyloses**, including starch, dextrin, glycogen, and cellulose; (2) **dextroses**, including dextrose, levulose, galactose; (3) **saccharoses**, including saccharose, lactose, maltose.

1. **Amyloses** $(C_6H_{10}O_5)_n$. — **Starch** forms about 10 per cent. of the body weight. It is a constituent in wheat, Indian corn, oats, cereals, plants, potatoes, peas, beans, and some fruits. In the presence of a ferment, such as ptyalin—in the saliva—starch is converted into maltose and dextrose, two forms of sugar.

Dextrin is a substance formed as an intermediary product in the change of starch into dextrose. It is divided into two varieties—**erythrodextrin** and **achroodextrin**

Glycogen, or **animal starch**, is a constituent of the animal liver, muscles, and tissues generally, particularly the tissues of the embryo.

Cellulose is found mostly in plants.

2. **Dextroses** $(C_6H_{12}O_6)$.—**Dextrose, glucose,** or **grape-sugar** occurs as irregular, warty masses, usually as a thick syrup. It is a constituent of the vegetable kingdom; generally found with fruit-sugar or levulose in fruits, as grapes, peaches, figs, cherries, mulberries, strawberries, etc. It is also found in honey, and is a normal constituent of liver, blood, and urine in small quantities, in health, and is an indication of the disease diabetes mellitus when found in larger amounts.

Levulose or **fruit-sugar** is associated with dextrose as a constituent of sweet fruits and honey.

Galactose is obtained when milk-sugar (lactose) is boiled with dilute sulphuric acid.

3. **Saccharoses.**—**Saccharose** or **cane-sugar** occurs as hard, crystalline granules. It is found in the juices of plants; in different grasses (sugar-cane); in the forest trees (maple-sugar); and in the roots and stems of plants (beet-sugar), etc.

Molasses is a product derived from the evaporation and refining of cane-sugar, as is caramel or burnt-sugar.

Maltose is formed from starch, when acted on by malt extract or the diastatic ferments in saliva and pancreatic juice. The diastatic ferment or diastase is a substance resulting from allowing the seeds of rye, wheat, barley, etc., to germinate in the manufacture of alcoholic liquors. This when formed acts on the starch and converts it into maltose and dextrin.
Lactose or **milk-sugar** is found only in the milk of mammalia. In the stomach of human beings, in the presence of the lactic acid bacillus, it is changed to lactic acid and then to butyric acid.

Fats.—**Fats** or **hydrocarbons** are organic bodies found in the tissues of both vegetables and animals. They are the most valuable food next to the carbohydrates, as a source of heat and energy, but are not so available or so easily digested. They are found in the subcutaneous tissues, marrow of bones, in and around the numerous internal organs, back of the eye-balls, the omentum, in milk; and in very stout persons they are found in the liver, kidney, heart muscle, and muscles of the extremities, also along arteries, veins, and nerves. Fat is found in the animal foods, such as, meat, fish, butter; in vegetable foods, as oils, cereals, and in the kernels of nuts,

Fats are compounds consisting of carbon, hydrogen and oxygen, the first being the main ingredient,

forming by weight about 75 per cent., while oxygen is present in very small amounts. The fat found in animals is a mixture of three neutral fats—**stearin, palmitin,** and **olein.** Each fat is derived from glycerin and the acid indicated by its name—*e. g.*, oleic acid, in the case of olein, etc.

When we speak of **saponification** we mean that a neutral fat has been treated with a superheated steam or saponified—*i. e.*, broken up into glycerin and a fatty acid, as stearic, oleic, or palmitic, the resulting acid depending on the neutral fat used.

Soaps.—Soaps are formed when saponification takes place in the presence of an alkali—*e. g.*, potassium or sodium hydroxid—the acid combines with the alkali to form a salt known as soap, the glycerin remaining in solution.

Soaps are salts. Soaps made with sodium hydroxid are hard, those with potassium hydroxid are soft. Those derived from stearin and palmitin are harder than those made with olein.

The Animal Fats.—Butter, cream, lard, suet, oleomargarin, cottolene, butterine, cod-liver oil, and bone-marrow are the animal fats of the most importance.

The Vegetable Fats.—Those most commonly employed are—olive oil, cotton-seed oil, linseed oil, cocoa-butter, and the oils derived from nuts, such as cocoanut oil, peanut oil, and almond oil.

The Proteins.—Proteins are found in both animals and vegetables, and contain most of the nitrogenous compounds essential for their physiologic needs. In the former they are found as constituents of the blood, tissues, bones, muscles, nerves, glands, and all other organs; in the latter, in nearly all parts of plants and seeds. They are represented in the vegetable food which we eat, as constituents of gluten of grain, etc.; in the animal food, as the lean and gristle of beef, the white of egg, casein of milk (the curd), etc.

Protein contains carbon, hydrogen, nitrogen, oxygen, sulphur, and some phosphorus. The chemic constituents, however, are so complex that a definite chemic formula, representing each ingredient, has not been satisfactorily determined. They are the most stable of the constituents of the body, and help to build up new tissues and replenish the quantity necessary to maintain the loss from waste of the old, resulting from the wear and tear of daily existence, through work, mental or physical, oxidation, elimination, etc. They are also converted into heat and energy, but are not so essential to the body for the former purpose, as the carbohydrates or fats. They are also converted into fat and stored up in the body for future use.

The proteins and their various tests and physical properties are too numerous to mention or discuss, especially as they are not essential to a nurse's knowledge. I shall simply mention the important ones or the ones of most interest as constituents of the more familiar tissues and foods, under the headings as follows:

Albumins, globulins, albuminoids.

Albumins: *Serum-albumin*—in blood, lymph, chyle.
Egg-albumen—in white of egg.
Lact-albumin—in milk.
Myo-albumin—in plasma of muscle.

Globulins: *Serum-globulins*—in blood serum.
Fibrinogen—in blood plasma (with serum-albumin and globulin).
Myosinogen—in muscle plasma (very nutritive).
Crystallin or *globulin*—in crystalline lens of eye.

Albuminoids: *Collagen and ossein*—in white fibrous tissue and bones.
Choridrin—in permanent cartilage.
Elastin—in fibers of yellow elastic tissue.
Keratin—in horny tissues and skin—as hairs, nails, scales, horns of animals, etc.
Caseinogen—in milk—contains phosphorus.
Vitellin—in yolk of egg—contains phosphorus.

Compound Albuminoids: *Hemoglobin*—in red cells of blood (coloring matter).

Mucin—in secretions of mucous membranes and epithelial cells.

Nuclein—in the nuclei of tissue cells and substance (rich in phosphorus).

Proteoses and Peptones.—These are resulting proteins formed during digestion by the action of the gastric and pancreatic juices upon the proteins as they pass through the process of digestion in the stomach and intestines.

Three coagulated proteins are formed when soluble proteins are acted upon by animal ferments, *e. g.*, fibrin, myosin, casein.

Fibrin.—This is formed from the soluble protein—fibrinogen—by the action of a special ferment. It is not found except when blood is withdrawn from the vessels or when coagulation occurs. Blood-clots following hemorrhage, by the action of the ferment on the fibrinogen, forming fibrin.

Myosin.—This is a protein derived from a soluble protein myosinogen. It occurs in muscles after death and accounts for the stiffness of the limbs—rigor mortis.

Casein.—This is formed as a result of the action of a special ferment—rennin, a constituent of the gastric juice—acting upon the protein—caseinogen—of milk. This is the ferment which splits milk into curds and whey or junket. The curds represent the solid portion or casein; the whey, the liquid portion. (See Digestion.)

INORGANIC COMPOUNDS

Water (H_2O).—Water is the most important inorganic substance essential to life. It is in the tissues and fluids of the body, comprising 75 to 90 per cent. of its weight. In a person weighing 165 pounds, 115

pounds of that weight will consist of water. It enters into the foods and liquids we assimilate; acts as a solvent for the various salts, carbohydrates, fats, proteins, etc.; aids in the absorption of fresh material into the blood and tissues; assists in dissolving and transferring the products of disintegrating tissues to the blood from which it is eliminated by way of the skin (perspiration), kidneys (urine), lungs, and intestines (feces).

The Inorganic Salts.—These are calcium phosphate, fluorid and carbonate; sodium chloride, phosphate, carbonate, and sulphate; potassium chlorid, phosphate and carbonate; magnesium phosphate and carbonate.

Salts enter into the formation of all tissues of the body. **Sodium chlorid**—common table salt—is the most important of the group. It is the chief salt found in the blood, lymph, and pancreatic juice. As a seasoning for food, it adds to its relish and thus promotes digestion. By a chemical process it helps to form the hydrochloric acid, and produces the alkalinity of the blood. **Potassium chlorid** is found in association with sodium chlorid throughout the tissues, and is a chemic constituent of muscle, nerve, and red corpuscles. **Calcium salts** are found as constituents of bones, teeth, cartilage, blood, milk, and other tissues. All of the above combinations are to be found throughout the body, but their various physiologic and chemic properties are not essential to the nurse's knowledge.

Phosphorus.—Phosphorus is found in the muscles, bones, nerve system, and blood, in various chemic combinations, as phosphates, also in both animal and vegetable foods.

Sulphur.—Sulphur is found in the body in the form of sulphates, which are derived from egg-albumen, milk, and certain vegetables.

Iron.—Iron is an essential constituent of the coloring matter (hemoglobin) of the blood, lymph, bile,

gastric juice, pigment of the eyes, hair, and skin. It is found in chemic combination only, as ferric acid and in organic compounds.

There are constituents of the body, aside from proteins, fats, carbohydrates, and inorganic salts, which can only be located by the various chemic analyses and tests. They are the substances resulting from the numerous and complicated changes continually taking place in the food we eat and water we drink, as a result of digestion, absorption, etc. They are carried to the tissues, where they perform their functions, and then are taken up from the tissues by the blood and carried to the skin (as perspiration), kidneys (as urine), lungs (as carbon dioxid), and intestines (as feces), to be eliminated as waste materials. These substances are: (1) Organic acids, *e. g.*, acetic, lactic, oxalic, butyric, in combination with alkalin and earthy bases. (2) Organic substances, *e. g.*, alcohol, glycerin, cholesterin. (3) Pigments found in the bile, urine. (4) Nitrogenized (crystalline), as urea, uric acid, xanthin, creatin, creatinin, and hippuric acid. (Brubaker.)

QUESTIONS

1. What does an analysis of the human body show it to consist of? To what groups of chemic and plant world do these compounds belong?
2. What do you understand by the term proximate principles?
3. What do the organic compounds consist of? The inorganic?
4. Name the chemical elements found in the human body.
5. What chemic compounds found in the human body represent the carbohydrates?
6. What do the carbohydrates contain and in what proportion?
7. What is the essential benefit derived from a nourishment rich in carbohydrates?
8. Name the three groups of carbohydrates?
9. Where is starch found in the vegetable and plant world?
10. Where is dextrose or grape-sugar found? Levulose or fruit-sugar? Saccharose or cane-sugar? Lactose or milk-sugar?
11. Do fats belong to the organic or inorganic group of compounds?
12. Are they as valuable as carbohydrates as a source of heat and energy?

13. Where is fat usually found in the human body? In the animal foods?

14. Does fat contain carbon, hydrogen, and oxygen?

15. Name the three neutral intermixed fats which are found in animals.

16. What do you understand by saponification?

17. How are soaps formed? What is the difference between a hard and soft soap?

18. Where are proteins found in the vegetable world? Animal world?

19. What do proteins contain?

20. Why are proteins so essential to the tissues of the body?

21. What are proteoses and peptones?

22. What percentages of water comprises the body weight?

23. Name the inorganic salts found by analysis in the body tissues.

24. Where is phosphorus found in the body tissues? Sodium chlorid? Sulphur? Iron?

CHAPTER III

METABOLISM—THE CELL, ITS STRUCTURE AND FUNCTIONS

METABOLISM

Metabolism is the term used to express the various and complex phenomena which are taking place within the protoplasm of the cells of the tissues throughout the body, whereby the food principles are transferred into simpler or complex compounds by the action of digestion, absorption, etc., and by which they are carried to the cells of the tissues where they are again converted into other bodies by an inherent function of the protoplasm of the cells, and produce energy that is later transferred into heat and activity.

Oxygen is essential to this chemic change going on within the cells. But oxygen is not a food.

When food is broken up into simple compounds it is termed **katabolism**; and when transformed into complex chemic bodies it is called **anabolism**. Both of the above changes are continually going on within the body and together comprise the processes of metabolism.

The body to develop, grow, and perform the various functions which constitute life, requires material for the tissues. This is derived from the food we eat and liquids we drink; and the oxygen we breathe from the air is essential to promote metabolism. The food is used by the tissues and the waste materials resulting from the processes of metabolism are eliminated.

Food, then, is not only used to create energy, heat, and activity, but it must replace the loss of tissue in the body which is continually occurring during the performance of the processes of life, from birth to old age. When this waste is not replenished by new tissue, the body cannot properly carry on its functions.

Every effort of the human body requires a certain amount of energy or force to bring about its performance. Thus a man in his daily work lifts a certain weight; the body cells must reproduce and furnish a proportionate amount of heat and activity necessary to accomplish this effort. This he obtains from the energy developed from a definite amount of food eaten each day.

Food is held together by a force called **potential energy.** When broken up into its more absorbable substances by the process of digestion, etc., so that the cells of the tissues can make use of it, to develop energy it is said to have **kinetic energy.**

It is essential to determine the heat value of various foods, in other words, to find out how much heat and energy will be derived from the different foods after their ingestion and digestion, etc. This may be determined experimentally by the use of an instrument known as a bomb calorimeter, the result being expressed in calories. A **calorie** is the amount of heat that is necessary to raise the temperature of 1 kilogram of water 1° C. (It is nearly equal to the amount required to raise one pound of water 4° Fahrenheit.) This expressed in mechanical force, means that a calorie would raise a ton about 1.54 feet, or that it is equal to 1.54 foot-tons.

The number of calories required to furnish heat and energy sufficient to accomplish a certain amount of activity varies, depending upon the age, sex, amount of work, mental and physical, and climatic conditions. It is essential to know how many calories are required to perform a certain amount of work from the taking

of various foods into the body, to make a proper application of dietetics in the feeding of healthy and diseased persons.

FIG. 1

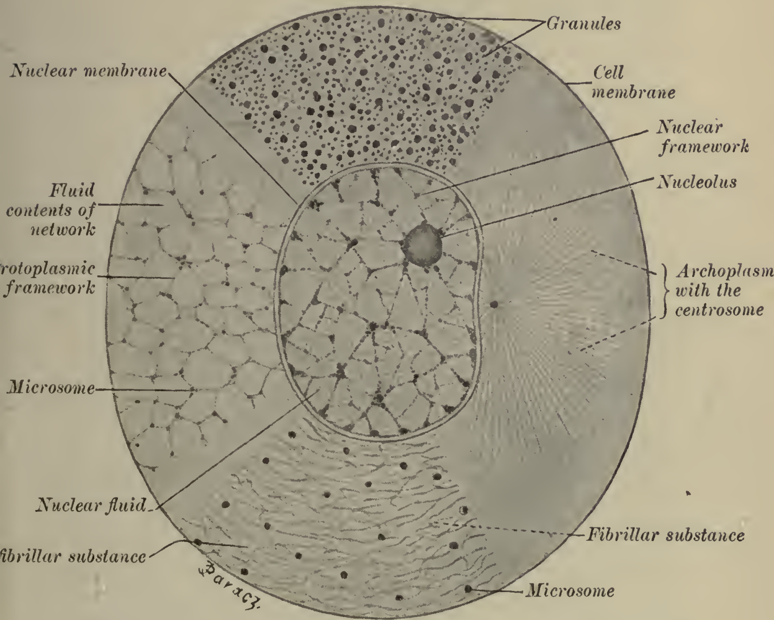


Diagram of a cell. The lower segment illustrates the fibrillar theory, the upper the granular theory, the left the foam theory. At the right the protoplasmic threads radiate from the centrosome. The nuclear network consists of nuclein, linin, and lantanin. (Symonowicz.)

THE CELL

The **cell, protoplasm** or **bioplasm** is the anatomic and physiologic bases of the body. All growth, repair, disintegration, heat, energy, and life of the tissues (whether normal or abnormal) depend upon the histologic cell as a unit to work upon. Cells are seen only

microscopically. They vary in size and may measure from $\frac{1}{3200}$ of an inch, the diameter of a red blood cell, to $\frac{1}{200}$ of an inch—the diameter of the large cells in the gray matter of the spinal cord. The structure of a cell consists of a gelatinous substance, usually homogeneous, called protoplasm or cytoplasm, containing a small spheric body, the nucleus, which latter contains the nucleolus. Young cells appear clean, mature cells contain, depending on the tissue they are found in, different substances, *e. g.*, fat-globules, granules of glycogen, mucigen, pigments, and digestive ferments. Cells possess the power of changing their shape, and are also capable of **growth**, **nutrition**, and **reproduction**.

Growth.—Newly reproduced cells are very small, but they soon grow, owing to their characteristic organization and surrounding medium, to resemble the normal adult cell of a given tissue.

Nutrition.—Cells not only must grow, but they have to repair or make up the loss from waste, etc. Growth and nutrition are dependent not only upon the power possessed by living material of absorbing its nutrition from the lymph, but also upon the property of taking that nutrition and converting it into material similar to its own, before waste took place, and then endowing it with physiologic functions. Thus we have a cell doing work, wasting as a result of such labor; repairing not only its own body, but renewing its powers of doing fresh work.

Reproduction.—Cells reproduce themselves by two methods, **direct** and **indirect** division. (See Figs. 2 to 16, pages 36 to 39.)

Direct division is seen when the nucleus of cells becomes narrowed and divides with a grouping of the nuclear elements. This is believed to occur only where cell disintegration occurs. Indirect division—this is called **karyokinesis**—is a complex process and its main feature is due to the centrosome of a cell becoming enlarged and in leaving the nucleus lying

in the surrounding protoplasm. The chromatin becomes contracted and is seen as V-shaped loops (chromosome), with thin closed ends pointed toward the common centre, the polar field. The mother stars are formed, which rapidly give origin to daughter stars, in which the chromatin can be seen as two separate nuclei grouped in a single mass of protoplasm; at this stage the protoplasm becomes constricted and two separate cells are seen lying in their own protoplasm. (See Figs. 2 to 8, pages 36 and 37.)

Cells of the animal and human body, or in fact all living protoplasms, possess the properties of **irritability, conductivity**, and **motility**.

Irritability or the power of responding to some external excitant. This can be mechanic, chemic, or electric; thus if the protoplasm acted upon be muscle, it will contract; if a gland, such as the parotid, saliva will be secreted; if a nerve, a sensation, as when we apply heat, cold, etc., to the skin; or other nerve activity, as seen in the contraction of the pupil when one looks suddenly at a bright light. It must be remembered that the degree of the response in the foregoing depends upon the protoplasm acted upon and the nature and strength of the irritating principle.

Conductivity is developed best in muscle and nerves, as seen when molecular disturbances occur at the extremity of the peripheral nerves, and are conducted to the brain, and the same phenomena arising in the brain are transmitted to the peripheral nerves.

Motility is the power possessed by cells of apparent active movement in response to natural causes, which scientists have not yet determined. This motility is best seen by microscopic technique and observed in the ameboid movements of the white cells of the blood, the waving of cilia, the activities of the spermatozoöns and ova during impregnation, or the commencement of pregnancy, etc.

QUESTIONS

1. Describe the term metabolism.
2. Is oxygen considered a food?
3. What do you understand by the term katabolism? Anabolism?
4. Why is food essential to the body's requirements?
5. What is meant by a calorie?
6. What term is used that expresses the determination of the amount of heat and energy to be derived from the different foods we eat and digest?
7. What factors will vary the determination of the number of calories required to furnish a certain amount of heat and energy from the food we eat?
8. What histologic unit underlies all the phenomena of physiologic life as: growth, repair, disintegration, heat, energy, and life of the tissues?
9. What functions is a cell capable of?
10. How do cells derive their nutrition? Repair waste? Renew its functional properties?
11. How do cells reproduce themselves?
12. Describe the term karyokinesis.
13. Name the properties of a cell.
14. What external stimulus will produce irritability in a cell?
15. What do you understand by the term as used in connection with the properties of a cell-irritability? Conductivity? Motility?

CHAPTER IV

TISSUES

To grasp an understanding of the various tissues properly, a brief description of the cells from which they are developed, embryologically, will be necessary.

The Ovum.—The ovary secretes a cell, the original cell of the female human body, called the **ovum.** The ovum consists of a limiting wall, the **vitelline membrane,** enclosing the protoplasm, **vitellus,** which consists of two parts—the **dentoplasm** or **nutritive yolk,** and the animal **protoplasm** or **formative yolk.** Within the vitellus is found the nucleus or **germinal vesicle,** which contains the nucleolus or **germinal spot.**

Before an ovum can develop into an offspring it must undergo numerous complex changes. The two most important phenomena are defined as **maturation and fertilization.**

Maturation.—Maturation or ripening is the process taking place in the ovum, which prepares it for the reception of the male element—spermatazoön, where its contained chromatin and a small part of the protoplasm are collected into the form of two minute structures called **polar bodies,** when a modified cell reproduction or karyokinesis occurs. This reproduction must take place before ova can be fertilized.

Fertilization.—This is the process in which the male and female units—the **ovum** and **spermatozoön**—unite to form a complete and perfect cell, by division, which ultimately develops into cells which form the tissues of the whole body.

The **male element** or **spermatozoön** or **spermium** consists of a head, middle-piece, and tail. After entering

Fig. 2

Fig. 3

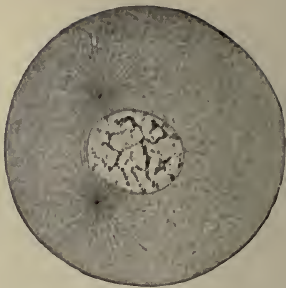


Fig. 4

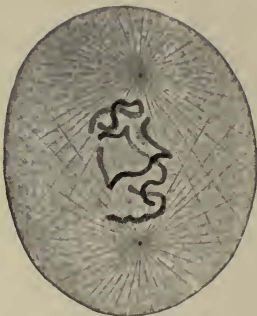
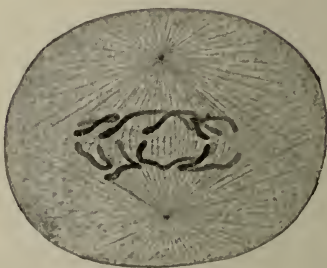


Fig. 5

Fig. 6



Diagrams illustrating cell division—karyokinesis.

Fig. 7

Fig. 8

Semidiagrammatic representation of the processes of cell and nuclear division (karyokinesis) in Ascaris megalocephala. (After Kostanecki.)

Fig. 2.—Resting cell.

Fig. 3.—Division of centrosome.

Fig. 4.—Prophase—centrosomes at the poles; radiation well-developed; chromatin net-work broken up into four chromosomes.

Fig. 5.—Mother-star stage (monaster); chromosomes arranged at the equator.

Fig. 6.—Metaphase; the longitudinally divided chromatin filaments moving toward the poles.

Fig. 7.—Anaphase; beginning of division of cell body.

Fig. 8.—Division of cell body almost completed; the central spindle shows the beginning of the intermediate bodies.

the ovum the head and middle-piece, representing the nucleus and centrosome, respectively, of a cell from the testicle (the male organ, the cells of which secrete the spermatozoön) form eight chromosomes. The chromatin of the germinal vesicle of the ovum also forms eight chromosomes. The process continues within the cell until thirty-two chromosomes are developed by longitudinal cleavage; these are subdivided into sixteen chromosomes, which enter each diaster or daughter cell.

Fig. 9

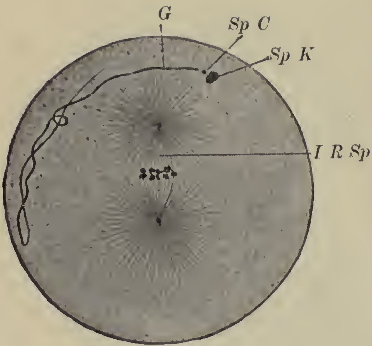


Fig. 10

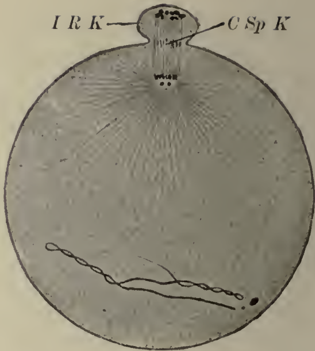


Fig. 11

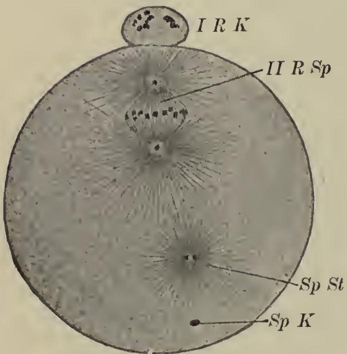
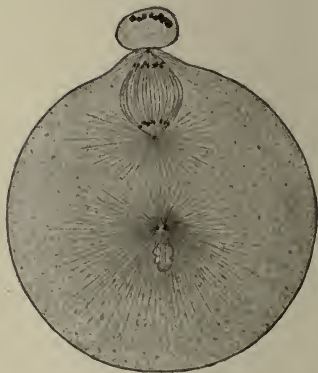


Fig. 12



Stages in the fertilization of Physa fontinalis. (After Kostanecki and Wierzejski.)

Fig. 9.—Mother-star stage passing into metakinesis for the formation of the first polar body. The spermatozoön is enclosed in the egg *in toto.*

Fig. 10.—Formation of first polar body; centrosome divided.

Fig. 11.—First polar body formed. Monaster stage for the formation of the second polar body. Sperm radiation is separated from the sperm nucleus.

Fig. 12.—Formation of the second polar body. Sperm radiation with two centrosomes near the vesicular sperm nucleus.

FIG. 13

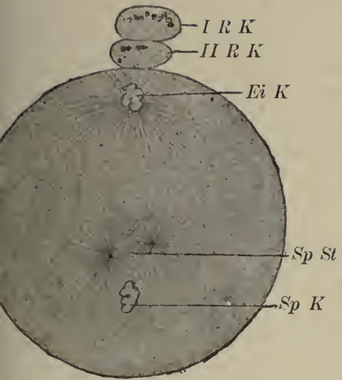


FIG. 14

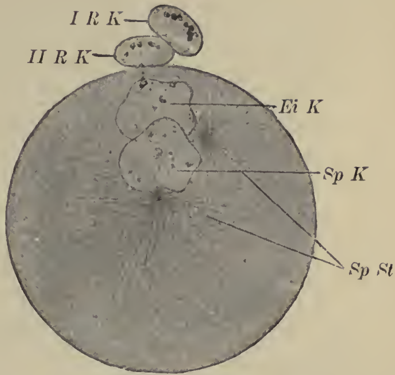


FIG. 15

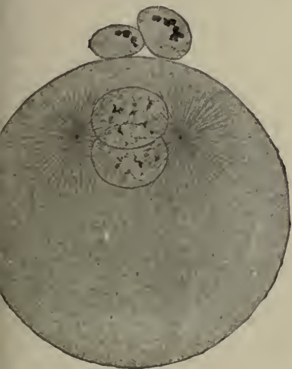


FIG. 16

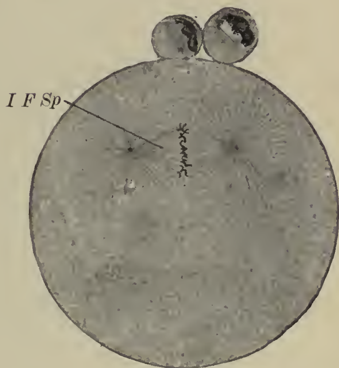


FIG. 13.—Two polar bodies above. Egg nucleus has become vesicular. Sperm radiation has increased in size.

FIG. 14.—Egg and sperm nuclei approach one another. The sperm radiation and the centrosomes move apart.

FIG. 15.—Egg and sperm nuclei closely approximated. The centrosomes arrange themselves on opposite sides.

FIG. 16.—The chromosomes of the egg and sperm nuclei form a monaster stage to give rise to two new cells.

CSpK, central spindle; *EiK*, egg nucleus; *IFSp*, first spindle after fertilization; *G*, tail of spermatozoön; *IRK*, first polar body; *IIRK*, second polar body; *IRSp*, first polar spindle; *IIRSp*, second polar spindle; *SpC*, centrosome of spermatozoön; *SpK*, sperm nucleus; *SpSt*, sperm radiation.

After fertilization the ovum divides and redivides into numerous cells, forming an irregular mass termed the **mulberry mass** or **morula.** The latter collection of cells divides again into an outer and inner cell mass called the **blastula.** The outer mass is supposed to disappear, while the inner continues to develop and forms two layers—an outer, the **ectoderm** or **epiblast,** and an inner, the **entoderm** or **hypoblast.** This is termed the **gastrula** or **diploblast.** A third layer is developed from the two former layers, each setting aside a few cells which develop the third layer, termed the **mesoderm** or **mesoblast,** that lies between the two layers. The formation receives the name of **blastodermic**·vesicle or **triploblast.**

All tissues of the body are composed of cells arising from the cells in the original three layers of the **triploblast** or **blastodermic vesicle.** Tissues, which are always studied microscopically, consist of cells held together by an intercellular cement, and perform a definite function; thus they may be supportive, as bone, etc., or functional, as the liver, etc. All the tissues to be seen and understood in their minute arrangement are first treated by histologic methods in the laboratory by hardening, sectioning, fixing, dehydrating, staining, etc., and are then observed under the microscope. This process is not essential to the nurse's knowledge, but should she desire a complete understanding of the subject she should refer to the standard works on histology.

Tissues are divided into **epithelial, connective, muscle,** and **nerve**

Epithelial Tissue or Epithelium.—They may be protective, as the cells of the skin and conjunctiva of the eye; secretive, as the cells of the pancreas, parotid gland, etc.; excretive, as the cells of the kidneys; to prevent friction, as those seen in the cells of the synovial sacs between the articulating cartilages of joints, peritoneum, and layers of pleura. Epithelial

cells line cavities that normally communicate with the air, except the pleural, peritoneal, and synovial sacs, and between the articulating cartilages of joints.

Epithelial cells are classified usually as: (1) **squamous**, simple and stratified; (2) **columnar**, simple, modified, and stratified; (3) **ciliated**, simple and stratified; (4) **prickle cells**; (5) **goblet cells**; (6) **transitional cells**; (7) **pigment**; (8) **neuro-epithelial**; (9) **glandular.**

Fig. 17

Flat epithelial cells isolated from the oral mucous membrane of man. × 375 (Szymonowicz.)

1. **Squamous Cells.**—(*a*) *Simple* squamous cells consist of a single layer of flattened elements, each containing a nucleus, usually situated in the centre and oval in form. They are found in the alveoli of the lungs, ventricle of brain, descending limb of Henle's loop in the kidney, and Bowman's capsule of kidney.

(*b*) The *stratified* squamous cells consist of layers of cells one on top of the other. The lowest layer, the germinal stratum, is arranged in columns, those above being polygonal. As the surface is reached the cells become more flattened, forming the squames or scales. These cells are usually found when they afford the most protection, as the skin (epidermis)

lining the mouth cavity, pharynx, esophagus, epiglottis, vocal cords, and the anus and vagina.

FIG. 18

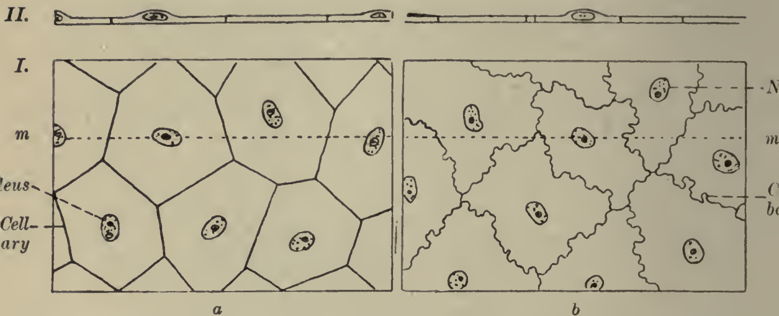
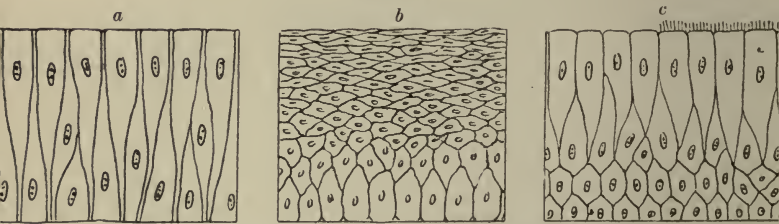


Diagram of flat epithelium. *I*, seen from above; *II*, seen from the side after transverse section on the line *m*. (*a*) cell boundaries as straight lines; (*b*) cell boundaries as wavy lines. (Szymonowicz.)

FIG. 19



Diagrams of epithelium: *a*, nuclei at various levels; *b*, stratified pavement epithelium; *c*, stratified cylindrical epithelium, ciliated at the right. (Szymonowicz.)

2. **Columnar Cells.**—(*a*) *Simple* columnar cells are arranged in tall columns consisting of a single layer with a nucleus situated at the base of each cell. They are found in the stomach and intestinal tract, anterior portion of the male urethra, glands of Cowper and Bartholin, prostate, gall-bladder, seminal vesicles, and many gland ducts. Low columnar cells are often called cuboidal.

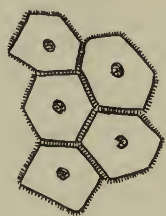
(*b*) *Modified* or *pseudostratified* cells are simple columnar or ciliated cells in which the nuclei are at different levels, thus giving the appearance of several layers of cells. These cells are found as ciliated elements in the oviduct, uterus, and middle ear, and as non-ciliated elements in the seminal vesicles and prostate.

(*c*) *Stratified* columnar cells consist of numerous layers of cells arranged one upon another. They are found in the lining membrane of the vas deferens (male), membranous urethra, and ducts of some glands.

3. **Ciliated Cells.**—(*a*) *Simple* ciliated cells are arranged in a single layer of columnar cells which have upon their exposed surface fine cilia or hair-like processes; they possess motion that is always directed toward the outlet of the organ in which they are located. They are found in the smaller bronchioles, spinal canal, accessory spaces of the nasal cavities, and the ventricles of the brain.

(*b*) *Stratified* ciliated cells are the same as the stratified columnar, with the cilia attached only to the cells of the exposed layer. These cells are found in the epididymis (male), first portion of the vas deferens (male), Eustachian tube, upper part of the pharynx, larynx, trachea, and nasal tract.

Fig. 20



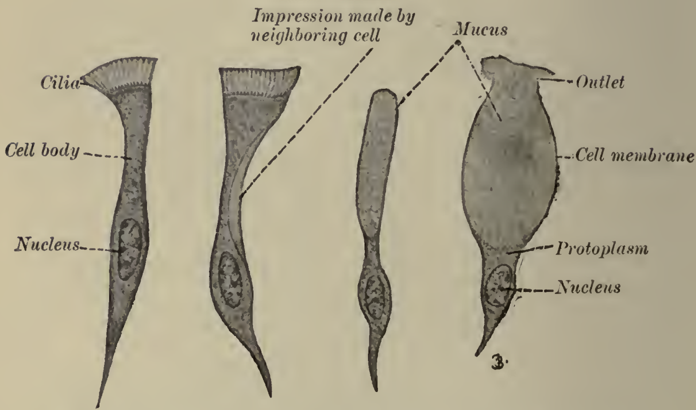
Prickle cells. (Gerrish.)

4. **Prickle Cells.**—These are polygonal elements that possess little spines, which project from the sides of the cells, and pass to meet spines of other cells, thus preventing the cells from meeting, at the same time forming intercellular bridges or spaces. They are found in the epidermis (skin) just above the genetic layer.

5. **Goblet Cells.**—These are cells resembling the cylindric type, distended with a secretion called

mucin. On filling they resemble a goblet. When the secretion has been discharged these cells become long and slender, the part containing the nucleus extending on either side. They are found in the gastro-intestinal and respiratory tracts.

Fig. 21



Two ciliated cells and two goblet cells isolated from the frog's esophagus. × 520.

6. **Transitional Cells.**—These are stratified cells belonging to neither the squamous or columnar groups. They are polygonal; found in the pelvis of the ureter, in the ureter, bladder, the first part of the male and almost the entire length of the female urethra.

7. **Pigmented Cells.**—These are polygonal or columnar in shape, the protoplasm containing pigment. They are found in the epidermis of the colored races, and around the nipple and genitals of the Caucasians, as polygonal cells, and in the retina of the eye where they assume the columnar shape.

8. **Neuro-epithelial Cells.**—These are cells which have become so differentiated as to perform a special sense function. These are found in the retina of the eye, in

the internal ear (hair cells), in the olfactory mucous membrane, in the taste-buds of the tongue, and tactile cells in the epidermis.

9. **Glandular Cells.**—These are found in the pancreas, liver, etc., and their shape varies according to the gland in which they are found.

Mucous Membranes.—All the surfaces of the gastro-intestinal and pulmonary tracts, genito-urinary apparatus, etc., within the body are covered by epithelial cells, called mucous membranes, These membranes are protected in the various organs by a superficial layer of cells—their variety depending on the tissue they are found in—which we have described above. Beneath this layer the cells rest upon a delicate **basement membrane**, the next layer is the **tunica propria** consisting of a layer of fibro-elastic tissue. Within this layer are lodged the capillary bloodvessels, nerves, lymphatic spaces or channels, and, in certain organs, glands and lymphoid tissue. These thin layers are seen resting on a fourth peripheral layer, called the **muscularis mucosæ**, consisting of involuntary (not under the control of the will), non-striated muscle tissue. This layer is sometimes wanting in some tissues. The above mucous membranes line cavities which communicate with the air. Their cells usually secrete a substance called mucin.

Glands.—Glands are considered under the classification of epithelial tissues. They are simply various shaped pouches or tubes of mucous membranes growing out from the superficial surface of the tissue in which they are located. All glands are lined with epithelial cells arranged in different groups, and possessing a physiologic function. These groups of cells are the units from which the organs develop their secretions.

Glands are subdivided into (1) **tubular**, simple, branched, coiled, compound; (2) **tubulo-alveolar**; (3) **alveolar**, or racemose glands, simple and compound.

These different shaped glands are lined by epithelial cells, depending on the situation and function. Their secretions are liquid, and may be **serous, mucous,** or **mixed,** which the lining cells secrete as needed by the organ to perform its physiologic function.

FIG. 22

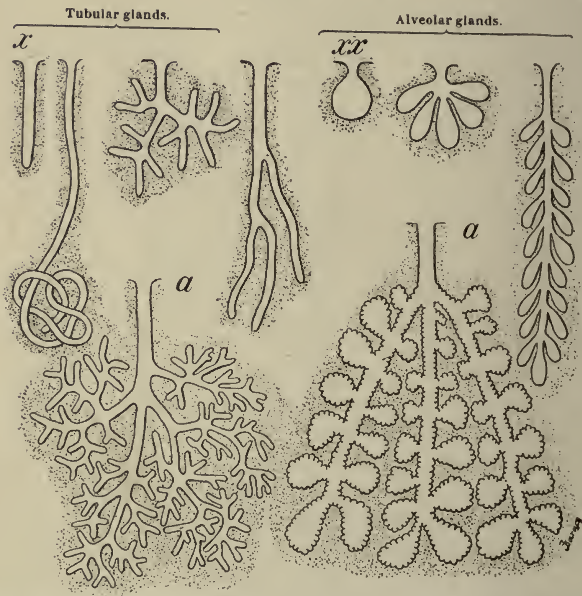


Diagram of various forms of glands; *a*, duct; *x*, simple tubule; *xx*, simple alveolus. (After Szymonowicz.)

Serous Membranes.—They are membranes covered by a single layer of flattened cells, with a large projecting nucleus; these cells are held together by a intercellular cement. They are termed **endothelial cells.** Serous membranes never have a basement membrane and line cavities that do not communicate with the air. These membranes appear smooth,

glistening, and transparent. Openings called stomata are said to be present between the cells, but they are supposed to be artefacts according to the latest teaching. Serous membranes line joint-cavities, bursæ, tendon sheaths, circulatory and lymphatic systems, and the pleural, pericardial, and peritoneal cavities.

Fig. 23

White fibrous tissue. (Gerrish.)

Fig. 24

Yellow fibrous tissue. (Queckett.)

Connective Tissues.—The **connective tissues** of the body are the elements entering into the formation of the more permanent structures of the body, such as bones, cartilages, ligaments, those holding fat in position, those used as coverings for muscles—as fascia, as sheaths for bloodvessels, and nerves, as supports for cells of glands and organs, and those binding membranes to underlying organs, as the pleura and peritoneum to the lungs and abdominal

organs respectively. The connective tissues are derived from the mesoderm.

They are classified as follows: (1) **fibrous**; (*a*) loose, (*b*) dense; (2) **yellow elastic**; (3) **mucous**; (4) **retiform**; (5) **mixed** or **areolar**; (6) **adipose** or **fatty**; (7) **lymphoid**; (8) **cartilage**; (9) **bone**; (10) **dentin (teeth)**; (11) **blood.**

1. **Fibrous Tissue.**—(*a*) The **loose** variety consists of fine thread-like fibers held in bundles by a small quantity of cement substance, and scattered throughout those groups of fibrils are seen a few cells. This variety is mostly for the support of capillary blood-vessels, the capsules of organs, and as a suppurative element in the tunica propria and submucosa in the mucous membrane of the respiratory and alimentary tracts.

(*b*) The **dense** variety differs from the former in the fibrils being thicker and the bundles larger. The dense is best seen in tendons of muscles, when it occurs as parallel bundles. Seen under the microscope on a cross-section the whole structure is seen surrounded by a loose sheath of fibers, the **epitendineum,** from which septa are seen passing into and dividing it into distinct or separate bundles of fibers, the **peritendineum.** The tendon cells are seen arranged in rows lying between the individual bundles of fibers.

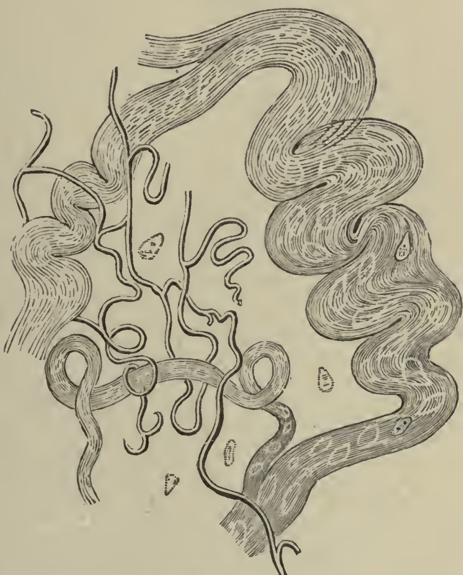
White fibrous tissue is very strong, inelastic, is pearly white in color, as seen when the skin is removed and dissections made of ligaments and tendons. It serves as a stocking-like covering to muscles, where it is termed **fascia**; and is seen as a bluish-white membrane reinforcing muscles and strengthening their insertions to bones, particularly in the region of joints, called an **aponeurosis.**

2. **Yellow Elastic Tissue.**—This, as the name implies, possesses elasticity; the fibrils are coarser than the white variety. It is found in the ligamentum nuchæ, which extends from the occipital bone to the spinous

processes of the cervical vertebra, along the vertebral column, where it is reinforced by white fibrous tissue, also in the ligamentum subflava, in the vertebral column, in bloodvessels, and in the skin.

3. **Mucous or Embryonic Tissue.**—This is found in the umbilical cord of the fetus. It is at first homogeneous, then later fibers both white and elastic develop, the former in bundles, the latter generally single. Among these fibers are a few scattered, mostly spindle-shaped, some stellate, and some round cells.

FIG. 25



Areolar tissue, composed of bundles of white fibrous tissue and branched strands of yellow fibrous tissue loosely intertwined. (Gerrish.)

4. **Retiform or Reticulum Tissue.**—This forms the frame-work of glands and gland-like organs. The fibrils are arranged in delicate bundles, in the meshes

of which are the functionating cells of the glands. The cells of this variety are mostly stellate.

5. **The Mixed or Areolar Tissue.**—This contains both white and elastic tissue. It shows a net-work of fine white fibrils, with elastic fibrils scattered throughout, and they are usually branched. The cellular elements scattered among these fibrils are stellate, plasma, and wandering forms. Areolar tissue is very fine, delicate, loose in texture, and binds the skin to the underlying fasciæ, and lies between muscles.

6. **Adipose or Fatty Tissue.**—This is white fibrous tissue, in which fat cells are deposited. In the living body it is liquid at the temperature of the body. It can only be seen in the tissues under the microscope after special preparation. It is essential to know, however, that it is found and can be seen as a yellowish layer beneath the skin (postmortem), surrounding organs, etc., which act as a covering or protection to them; it has a wide distribution and is never found in the ear, eyelid, or genitalia (male), and is always found back of the eye-ball and in the kidney, no matter how poorly nourished an individual may be, even to the extent of starvation.

7. **Lymphoid Tissue.**—This is made up of a net-work of reticulum, holding among its fibers the white blood-cells or leukocytes. The cells seen are mostly small lymphocytes, and some large lymphocytes and poly-nuclear cells. (See blood, page 221.) There are three varieties of lymphoid tissue: (*a*) diffuse; (*b*) solitary follicles; (*c*) Peyer's patches; and lymph nodes.

(*a*) The **diffuse** variety is found in the tunica propria of the mucous membrane of the alimentary and respiratory tracts, the medulla of the thymus body, and the greater portion of the tonsil and spleen. (*b*) **Solitary** follicles are found in the alimentary and respiratory tracts, spleen, and tonsils. (*c*) **Peyer's patches** consist of a collection of solitary follicles clearly outlined from the surrounding tissue. They are found

in the wall of the ileum (the terminal portion of small intestines which opens into the cecum). Lymph nodes (glands). (See Lymphatic System.)

8. **Cartilage.**—Cartilage is not as compact or strong as bone. It is more yielding; thus it will be found in different parts of the body when this firm yet pliable property is essential to the function of an organ. We see it in the cartilages of the larynx, where one may readily understand how its structure must be more or less elastic owing to the constant action of the muscles upon the cartilages and their change in relationship during talking, singing, etc., and its value can be appreciated when placed between bones, as a shock absorber; demonstrated by the intervertebral disks between each vertebra.

In studying the structures of cartilage it is considered under perichondrium, cells, and intercellular substance. The **perichondrium** is a fibrous sheath which surrounds cartilage and corresponds to the periosteum of bone. It is divided into an outer fibrous layer containing few cells, and an inner portion or chondrogenetic layer, consisting of flattened and elongated or spindle-shaped cells. These are the **chondroblasts** or **cartilage cells.** The latter cells are seen just beneath the perichondrium, where they appear as flat cells, then as the centre of the cartilage is reached they become more oval or even round. Each cell is rich in protoplasm and contains one or more vacuoles. The cell is surrounded by a capsule, and a small space intervenes between the cell and the capsule called a lacuna. The **intercellular substance** consists of a homogeneous mass in the hyaline cartilage, and of white fibrous and yellow elastic fibers, in the white fibrocartilage and yellow fibrocartilage respectively.

There are three varieties of cartilage: **Hyaline, white fibrocartilage,** and **yellow fibro** or **elastic.**

The **hyaline cartilage** is pearl blue in color, is elastic, and cuts with a knife. It is found in the body covering

articular surfaces of bones, which line joint-cavities; in costal cartilages as found between the ribs and breast bone or sternum; in cartilages surrounding the trachea (windpipe); and in most of the laryngeal cartilages. It may ossify in old age.

The **white fibrocartilage** is not very plentiful and acts as a structure to deepen joint-cavities, as interarticular fibrocartilages and intervertebral disks.

Yellow fibrocartilage is found wherever elasticity is required, as in the epiglottis, Eustachian tube, ear, and smaller laryngeal cartilages. It never ossifies.

Cartilages are very poorly nourished, as they do not contain many bloodvessels, except in the perichondrium; and except when the cartilage is developing. No lymph channels are present.

NOTE.—Muscle, osseous, and nerve tissues are described under the chapters on Muscles, Bones, and Nerves respectively.

QUESTIONS

1. What do you understand by the term maturation? Fertilization?
2. What three layers of cells are developed from the ovum after maturation and fertilization are completed?
3. What are the tissues of the body divided into?
4. Name the functions of epithelial tissue.
5. In what cavities of the body are epithelial cells found?
6. Give the classification of epithelial cells.
7. How do ciliated cells differ from other cells?
8. What is characteristic of stratified cells?
9. In which direction do the motion possessed by ciliated cells point?
10. What layers of tissues enter into the formation of a normal mucous membrane?
11. Which layer contains bloodvessels, lymphatic spaces, nerves, glands, and lymphoid tissue in certain organs?
12. Which layer contains involuntary non-striated muscle tissue?
13. Give the subdivisions of glands.
14. What are the three varieties of secretions from glands?
15. How do serous membranes differ from mucous membranes?
16. What name is given to the type of cells covering the serous membranes?
17. Where are serous membranes found throughout the body?

18. What is the function of connective tissue?
19. Give the classification of connective tissues?
20. Where is yellow elastic tissue found?
21. What tissue enters into the frame-work of glands and gland-like organs?
22. Is adipose tissue liquid at the temperature of the body?
23. What structures of the body are always free from fat?
24. Name the three varieties of lymphoid tissue.
25. Is cartilage as strong as bone?
26. What is the essential property of cartilage as found in the body?
27. Name the varieties of cartilage?
28. Describe hyaline cartilage and where is it found? Does it ossify?
29. Where do you find white fibrocartilage? Yellow fibrocartilage?
30. What is the function of mixed or areolar tissue?

CHAPTER V

OSTEOLOGY—THE DESCRIPTION OF BONES AND BONE TISSUE

THE bones entering into the supportive structure of the body are held in close relation with each other by means of ligaments and muscles. Thus the skeleton consists of a strong, firm frame-work, possessing all manner of movements due to the action of the attached muscles and the leverage of the bones, allowed by the ligaments holding the bones in relation with one another. The body skeleton consists of two hundred and six bones, as follows:

Axial skeleton	Vertebral column	26	
	Skull	22	
	Hyoid bone	1	
	Ribs and sternum	25	
			—74
Appendicular skeleton	Upper limb	64	
	Lower limb	62	
			—126
Auditory ossicles (bones of ear)			6
	Total		206

The patellæ, two in number, are included in this list, but not the sesamoid bones. The latter are small bones (shaped like sesame seed) found embedded in tendons covering the knee, hand, and foot.

Classes of Bones.—Bones are divisible into four classes: **long, short, flat,** and **irregular.**

Long Bones.—These are found in the limbs, they support the weight of the trunk and form a system of

levers which permit the power of locomotion and prehension. Long bones possess a shaft and an upper and lower extremity. The shaft or the **diaphysis** is cylindrical, containing in the centre a hollow cavity, the **medullary canal**, in which during life is the bone-marrow. Surrounding this is dense compact tissue of considerable thickness, but not so thick near the extremities. The **extremities** or **epiphyses** are usually expanded to enable one bone to articulate with another and to afford attachment of muscles. They are usually developed from separate centres of ossification called **epiphyses.** Examples of long bones are the **femur** or thigh bone, the **humerus** or bone of the arm, the **clavicle** or collar bone, the **radius** and **ulna** (bones of the fore-arm), the **tibia** and **fibula** (bones of the leg), the **meta-carpal, metatarsal,** and **phalanges** (the small bones of the hand and foot) respectively.

Short Bones.—These are found in that portion of the body where strength and compactness are required and the motion of the part is limited, as the bones of the **carpus** (wrist) and **tarsus** (instep). These bones consist of cancellous tissue covered by compact bone. They are held firmly together by ligaments. Some include the patellæ and sesamoid bones under this variety.

Flat Bones.—These are found wherever protection is required, or a broad surface for the attachment of muscles is essential, as the bones of the skull and the scapulæ (shoulder-blade). Flat bones are composed of two thin layers of compact tissue, between which is a variable amount of cancellous tissue. In the bones of the skull these layers of compact tissue are termed the **tables of the skull**; the innermost is thin and called the **vitreous table.** The cancellous tissue between the layers is called the **diploë.**

The flat bones are the **occipital, parietal, frontal, nasal, lacrymal, vomer, scapula, sternum, ribs,** and some authors include the patella.

Irregular Bones.—These are of varying shapes which cannot be classified under any of the preceding groups. They consist of a layer of compact tissue externally enclosing cancellous tissue.

The irregular bones are: the **vertebræ, sacrum, coccyx, temporal, sphenoid, ethmoid, malar, maxilla, mandible, palate, turbinates,** and **hyoid.**

Surfaces of Bones.—The examination of a bone will show numerous depressions and elevations upon its surface, which for purposes of study have been classified into the following eminences and depressions: (1) articular; (2) non-articular. Examples as follows:

Articular.—

Eminences	Head of femur. Head of humerus.
Depressions	Glenoid cavity of scapula. Acetabulum of os innominatum.

Non-articular.—

Eminences	Tuberosity is a broad, rough, uneven elevation. Tubercle is a small, rough prominence. Spine is a sharp, slender, pointed eminence. A ridge, line, or crest are narrow, rough elevations along the surface.
Depressions	Notches. Fossæ. Grooves. Furrows. Fissures. All are of variable form.

The articular eminences and depressions are the extremities and cavities of bones which enter into the formation of joints respectively. The non-articular eminences are to increase the surface of the bone for the attachment of muscles and ligaments; the depressions usually receive, hold, or keep in position tendons or muscles, and transmit bloodvessels and nerves.

Composition and Structure of Bone.—Bone in the fresh state is pale pink in color, when dried it is grayish white. The constituents of dried bone are 31 per cent. organic matter and 69 per cent. inorganic matter. The former is represented by bloodvessels and connective tissue, and proteins, such as collagen, ossein, elastin; the latter by mineral salts, *e. g.*, tricalcium and magnesium phosphate, calcium carbonate, and some soluble salts. These ingredients may vary with the age of the individual. Thus in the child there is an increase in the organic matter over the mineral constituents, while the mineral salts predominate in bones of the adult. This absence of salts in the bones of children accounts for the elasticity of the bones, and when fractured they bend rather than break after an injury. This can be seen when a fractured limb, exposed to the *x*-rays, will appear as a twig bent, but no distinct break is seen (this is termed a green-stick fracture). On the other hand in extremely old persons there is a tendency to fracture of the bones, due to the increase of mineral salts over the organic constituents, rendering them brittle, and unable to withstand the slightest strain without fracture. Rickets is another example of this decrease in lime salts in the bones. It is a disease occurring in children mostly, characterized by a bending of the long bones, and deformity of the limbs, as a result of insufficient and improper nourishment. **Bone** belongs to the connective-tissue group, and is derived from the mesoderm layer of the tripoblast, the primitive vesicle of the embryo.

Periosteum.—All bones are surrounded by a fibrous sheath, called the **periosteum**, enclosing the bone substance; the latter is composed of cells and intercellular substance. The **periosteum** consists of two layers: an outer fibrous, supporting bloodvessels, an inner or genetic layer, rich in cells and blood capillaries. The cells in the latter become the future **osteoblasts**

that develop the osseous tissue by a process of cell secretion. The genetic layer gives off bundles of fibers which pierce the layers of bone at right angles and bind them together. These are called **Sharpey's** fibers.

Bone is classified as to its composition into **cancellous** or **spongy, compact** or **solid.**

Cancellous or Spongy Bone.—This consists of spicules forming a net-work similar to a sponge. These spicules have a fibular structure, and between them are small spaces called lacunæ (little lakes), which are filled in the living state with osteoblasts. The cancellous bone is found in the head of long bones, the centre of flat bones, and around the medullary cavity. In the centre of all long bones is a hollow cavity called the medulla; it contains marrow. This medullary cavity is lined with a fibrous layer of tissue called the **endosteum,** which covers the net-work of spongy bone surrounding the medullary canal.

Compact or Solid Bone.—This is the stronger of the two varieties and forms the outer surface of the long bones. It is arranged in layers called lamellæ, and can only be studied in section after preparation; and when observed under the microscope it will present a series of lamellæ arranged around a central opening, called the **Haversian canal.** These carry bloodvessels in a longitudinal direction throughout the bone, and communicate with each other. Between the Haversian canals are **lacunæ**—lined with osteoblasts—they communicate with each other and the Haversian canals by means of small canals—called **canaliculi.** Just beneath the periosteum the lamellæ of bone are derived from it. These layers have between them lacunæ with canaliculi connecting each other. The most external lamellæ present depressions termed **Howship's foveæ** or **lacunæ;** these are filled with large bone-destroying cells called **osteoclasts.** Haversian canals are absent in the external lamellæ beneath the periosteum, but large canals are present, containing blood from the periosteum—**Volkmann's canals.**

The Haversian canals are occupied by bloodvessels, nerves, and lymphatics, except in the region of the heads of long bones; owing to their absence this portion of the bone is better enabled to withstand the pressure imposed upon it. The above arrangement of canals is termed the **Haversian System.**

The **medullary cavity** is a large space within the centre of the long bones. It is lined by a fibrous layer, the endosteum, and contains the nutrient marrow.

Marrow is of two varieties, red and yellow. The former color is seen in healthy, young individuals, the latter occurs in those beyond the prime of life. The presence of a great amount of fat causes the latter to assume its yellow color. The cellular elements are few or are wanting. In disease it may become red. It is derived from the endosteum between the compact bone and the medullary cavity, and consists of a delicate frame-work of reticulum holding a compact capillary plexus and cells. These cells are classified as: **Marrow cells** or **myelocytes, nucleated red blood cells** or **erythroblasts, white blood cells** or **leukocytes, myeloplaxes.** (For a better knowledge of these cells the reader is referred to the standard works on histology or hematology.)

The function of red marrow is to produce erythrocytes, granular leukocytes, and to store fat. Bones are nourished by an artery which enters the nutrient foramen, seen on the surface of bones, and by branching into smaller vessels, called capillaries, pass into the Haversian canals; other vessels enter Volkmann's canals to nourish the most external lamellæ beneath the periosteum.

BONES OF THE HEAD

The skull is divided into two parts: the **cranium** and **face;** the former lodges and protects the brain and its membranes, bloodvessels, and nerves; the

bones of the face partially surround the orbital cavity and form the walls of the nasal and oral cavities.

The cranium has eight bones.

(*a*) Unpaired:	(*b*) Paired:
Occipital.	Temporal.
Sphenoid.	Parietal.
Ethmoid.	
Frontal.	

The face has fourteen bones:

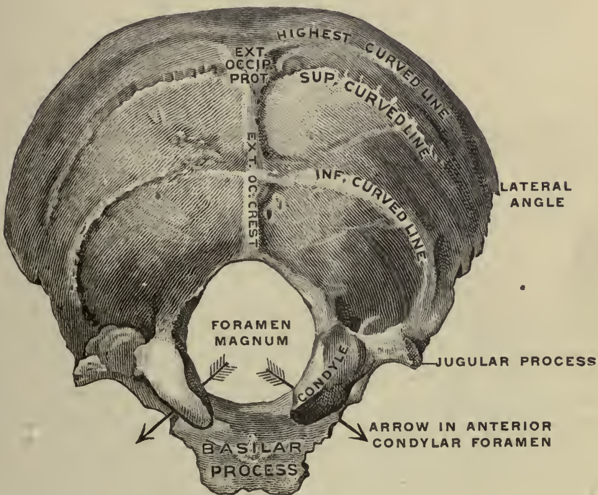
(*a*) Unpaired:	(*b*) Paired:
Vomer.	Nasals.
Mandible.	Maxillæ.
	Lacrymals.
	Malars.
	Palates.
	Turbinates.

The Bones of the Cranium.—The Occipital Bone.—This is situated in the back part and base of the skull, is flattened, lozenge-shaped, bent on itself, presenting an internal or cerebral surface, which is concave, and an external or posterior surface, which is convex; four borders and four angles. Below and in front the bone shows a large oval opening, called the foramen magnum, for the passage of the spinal cord and membranes, spinal accessory nerves, and two vertebral arteries. On either side of the anterior boundaries of the foramen magnum are two condyles which articulate with the atlas (first cervical vertebra). Anteriorly a rough process of bone (the basilar) articulates with the body of the sphenoid and temporal, and the posterior border of the occipital bone articulates with the parietal bones on either side.

The Parietal Bones.—These are paired one on either side, together forming the median portion of the roof

and sides of the skull. Each is roughly quadrilateral, and presents two surfaces—external and internal, four borders and four angles. This bone articulates, at the anterior border, with the frontal bone; posterior border, with the occipital bone; internal border, with opposite bone; inferior border, great wing of sphenoid; squamous portion of temporal, and the mastoid portion of the temporal.

FIG. 26

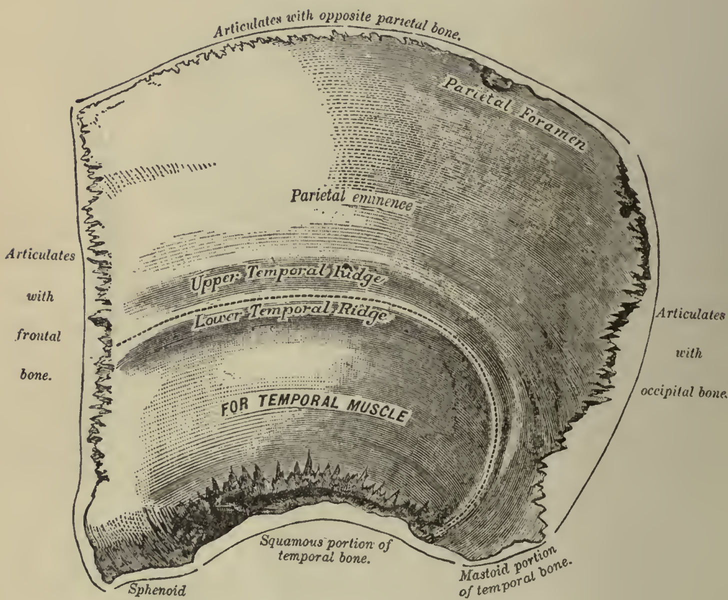


The occipital bone, viewed from below. (Spalteholz.)

The Frontal Bone.—This forms the forehead, and also enters into the roofs of the orbital and nasal cavities. Its anterior surface is convex and the convexity is greatest on either side, where the rounded frontal eminences are to be seen, separated by a slight depression below from the superciliary ridges. The latter ridges are just above the orbits and afford protection to them from injury. In the middle line between the two ridges is a smooth surface—the glabella.

The orbital arch ends in extremities called the internal and external angular processes. The frontal sinuses (hollow spaces) which communicate with the nasal cavities contain air, and are lodged in the frontal bone just above the orbital arches. The frontal bone articulates with twelve bones — the parietals, the sphenoid, the malars, the nasals, the superior maxillæ, lacrymals, and ethmoid.

Fig. 27

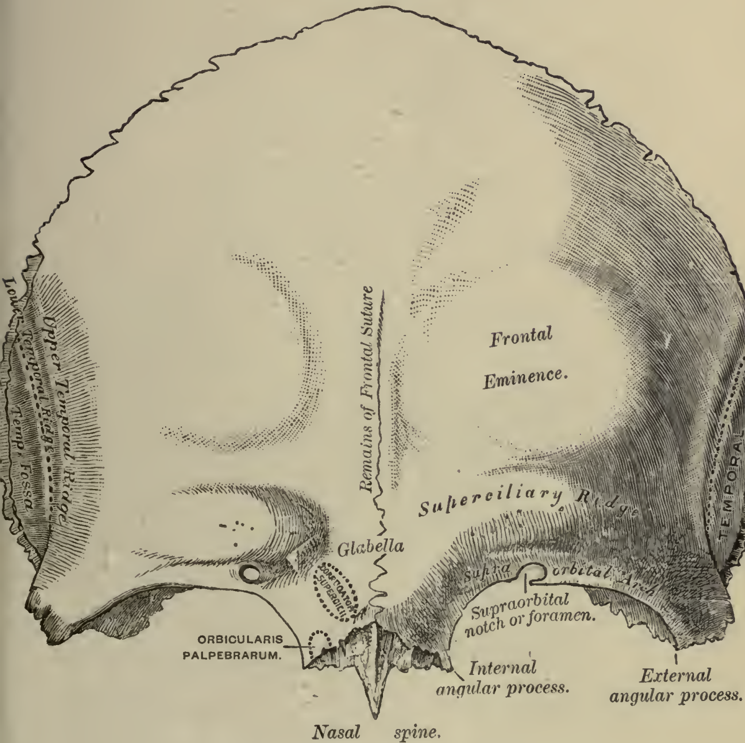


Left parietal bone, external surface. (After Gray.)

The Temporal Bones.—These are paired, assist in forming the sides and base of the skull, and contain the organ of hearing. They present three parts—**squamous, petromastoid,** and **tympanic.**

THE SQUAMOUS PORTION.—This is scale-like in form and very thin. Its external surface is convex, smooth, and affords attachment to the temporal muscle and

FIG. 28

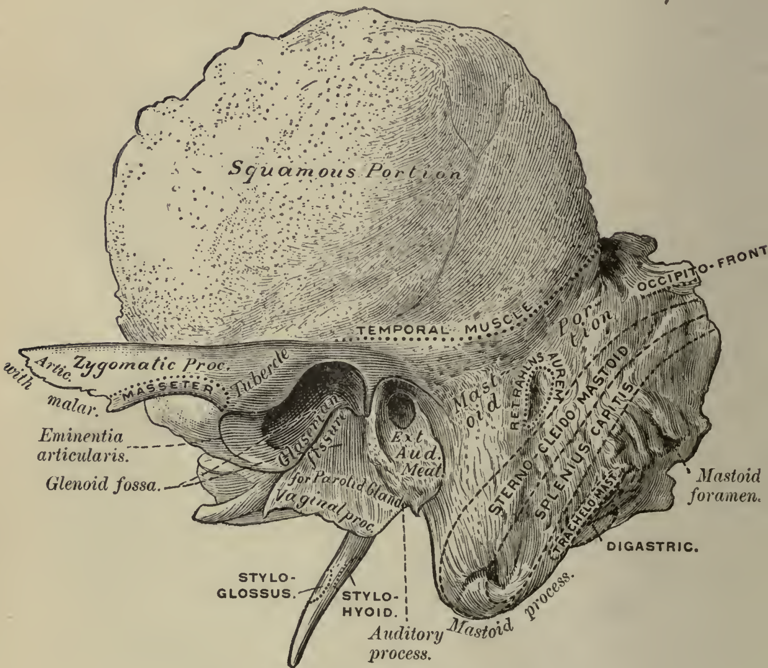


Frontal bone. Outer surface. (Gray.)

bounds part of the temporal fossa. Proceeding forward from the lower part of this portion of the bone is a long arched process of bone, the **zygoma** or **zygomatic process.**

THE PETROMASTOID PORTION.—This consists of the **mastoid portion**, the thick, conical process of bone behind the external opening of the ear, and a pyramidal portion called the **petrous portion**, forms part of the floor of the skull. The **mastoid portion** contains on

FIG. 29



Left temporal bone: outer surface. (Gray.)

section a number of cellular spaces communicating with one another, called the mastoid cells. The mastoid cells open into the middle ear, and contain air. They are lined with a prolongation of mucous membrane from the tympanum, which extends into them through an opening, by which they communicate

with the cavity of the tympanum. The **petrous portion** is a pyramidal process of bone wedged in at the base of the skull, between the sphenoid and occipital bones. It has a foramen—internal auditory—for the passage of the facial and auditory nerves.

THE TYMPANIC PORTION.—This is placed in front of the anterior surface of the petrous portion. It bounds the external auditory meatus in front, below and behind, and lodges the tympanic membrane (ear-drum).

The **glenoid fossa** is a depression formed by the squamous part of the temporal and behind by the tympanic portion. It is covered with cartilage (squamous portion) and articulates with the condyle of the mandible.

The Sphenoid Bone.—This wedge-like bone is placed across the base of the skull near its middle, and binds the other cranial bones together. It assists to form the cavities at the base of the cranium, orbits, and nasal fossa, and has foramina and fissures for the passage of six pairs of cranial nerves. It consists of a solid body of bone, with a thin pair of lesser and greater wings. It articulates with twelve bones, all those of the cranium and five of the face; posteriorly, with the occipital and temporals; anteriorly, with the ethmoid, palatals, frontal, and malars; laterally, with the temporals, frontal, and parietals; inferiorly, with the vomer and palatals. The upper surface of the body of the sphenoid supports the pituitary body, and the circular and cavernous sinuses, the latter enclosing the internal carotid artery.

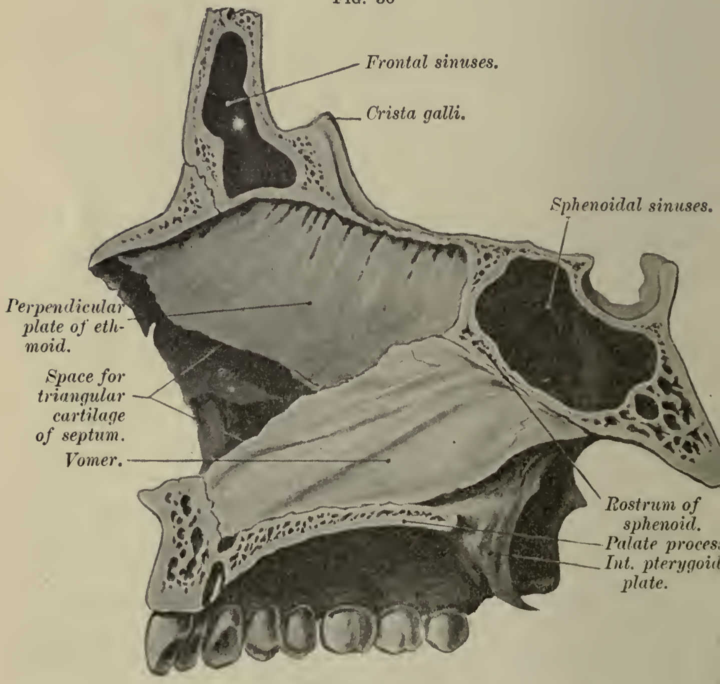
The Ethmoid Bone (sieve-like).—This projects down between the orbital plates of the frontal, and enters into the formation of the floor of the anterior cranial fossa, the orbital, and nasal cavities. It is a very small, frail bone. Its upper surface lodges the olfactory bulb and portions of the olfactory tract. The filaments of the olfactory nerve (sense of smell) pass

5

through foramina in the cribriform plate to be distributed to the mucous membrane of the nasal cavities. The anterior, middle, and posterior ethmoidal cells are lodged in this bone; they communicate with the nasal cavities. It possesses a perpendicular plate, which forms a portion of the nasal septum between the two nasal cavities.

Bones of the Face.—The Two Nasal Bones.—These form the bridge of the nose. They are very small but strong considering their size.

Fig. 30

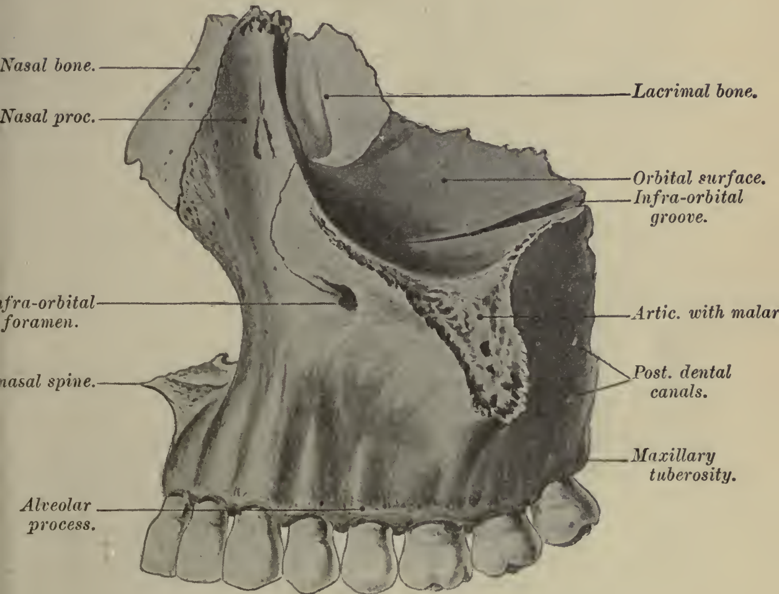


Vomer *in situ*.

The Vomer.—This is a thin flat bone which joins with the perpendicular plate of the ethmoid bone, and

septal cartilage to complete the septum between the nasal cavities. It articulates with the sphenoid, ethmoid, both palates, superior maxillæ, and with the septal cartilage of the nose.

FIG. 31



Nasal and lacrymal bones *in situ*. (Gray.)

The Lacrymal Bones.—These bones are paired. They are very small and thin, found at the anterior and internal part of the orbit. The outer surface of this bone forms with the lacrymal notch of the superior maxilla the orifice of the nasal duct. (The latter is the entrance of the canal for the passage of the tears from the eye to the nasal cavity.)

The Maxillæ Bones.—They are paired, irregular in shape, and the principal bones of the face, each supporting the upper teeth of one side, helping to form

the floor and outer walls of the nasal fossæ and the hard palate or roof of the mouth, in conjunction with the palate bone, also a part of the floor of the orbit. It contains the hollow space just above the canine tooth, called the antrum of Highmore. The latter communicates with the nasal chamber and is frequently the seat of inflammation. This bone articulates with its fellow of the opposite side, the nasal, lacrymal, frontal, ethmoid, palate, malar, vomer, inferior turbinate, and sometimes the sphenoid.

The Palate Bones.—They are two in number situated at the back part of the nasal fossæ; they are lodged between the maxilla and the pterygoid processes of the sphenoid. Each bone assists in the formation of the floor and outer wall of the nasal cavity, roof of the mouth, and floor of the orbit.

The Turbinated Bones.—They are situated one on each side of the outer wall of the nasal fossæ. Each consists of a layer of thin, spongy bone, curled upon itself like a scroll—hence its name, turbinated

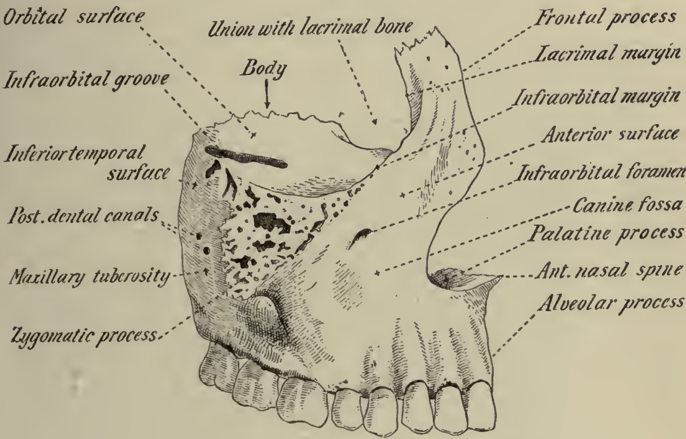
The Malar Bone.—This bone is quadrangular, and is situated at the upper and outer part of the face. It forms the prominence of the cheek, part of the outer wall and floor of the orbit, and part of the temporal and zygomatic fossæ. It articulates with the frontal, sphenoid, temporal, and the maxilla.

The Mandible or Lower Jaw.—This is the largest and strongest bone of the face. It consists of a horizontal portion called the body, which forms the chin, and two perpendicular rami, which join the body to form the angle of the jaw. It articulates by its condyles with the glenoid cavity of the tympanic portion of the temporal bone. The horizontal portion serves for the lodgement of the lower teeth.

The Hyoid Bone.—This is a bony arch, shaped like a horseshoe, and consisting of five segments—a body, two great cornua, and two lesser cornua. It is situated in the neck in the receding angle below the chin. It is

supported by the stylohyoid ligaments attached to the lesser cornua of each side. The attachment of muscles help to hold this bone in position and acts as a fixed point for the muscles of swallowing and articulating. Below it is attached to the larynx by the thyrohyoid membrane. The hyoid bone can be felt just above the Adam's apple (pomum Adami). It also affords attachment to the muscles which lower the jaw, depress the tongue, and aid as accessory muscles of respiration.

Fig. 32

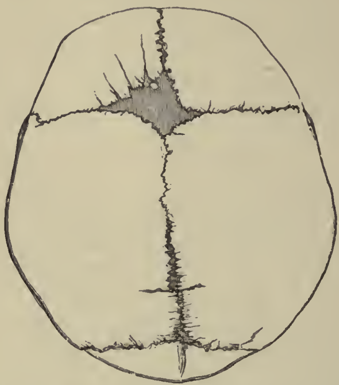


Right upper jaw bone, maxilla, from without.

The Skull as a Whole.—At birth the skull is large in comparison with the other parts of the skeleton. The face is small and equals only about one-eighth of the bulk of the cranium, as compared to the size of the face in the adult which equals about one-half of the size of the skull. Ossification of the bones of the skull in the infant is not complete; they are held together by membranous tissue and these intervals between the bones are termed fontanelles. There are six: Two,

anterior and posterior, and four, an anterolateral and posterolateral on either side.

Fig. 33



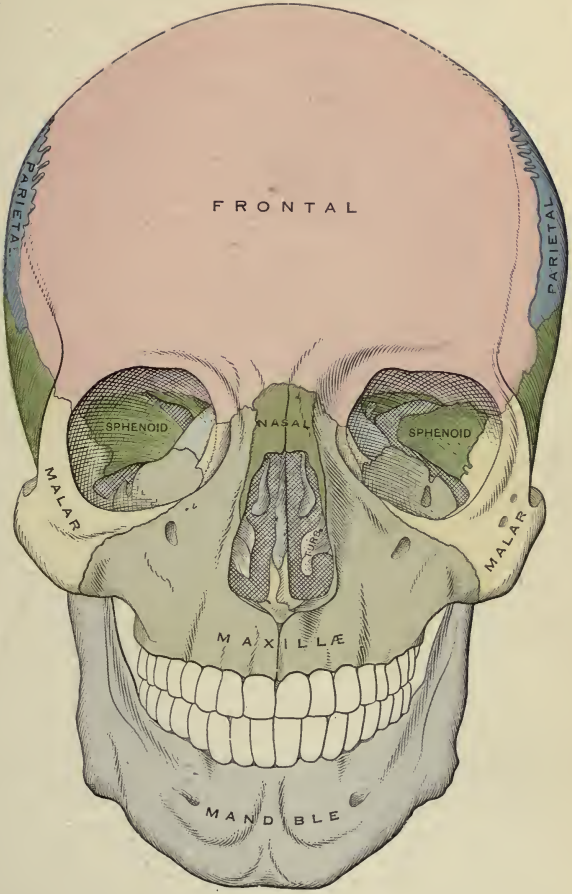
Skull at birth, showing the anterior and posterior fontanelles. (Gray.)

Fig. 34

The lateral fontanelles. (Gray.)

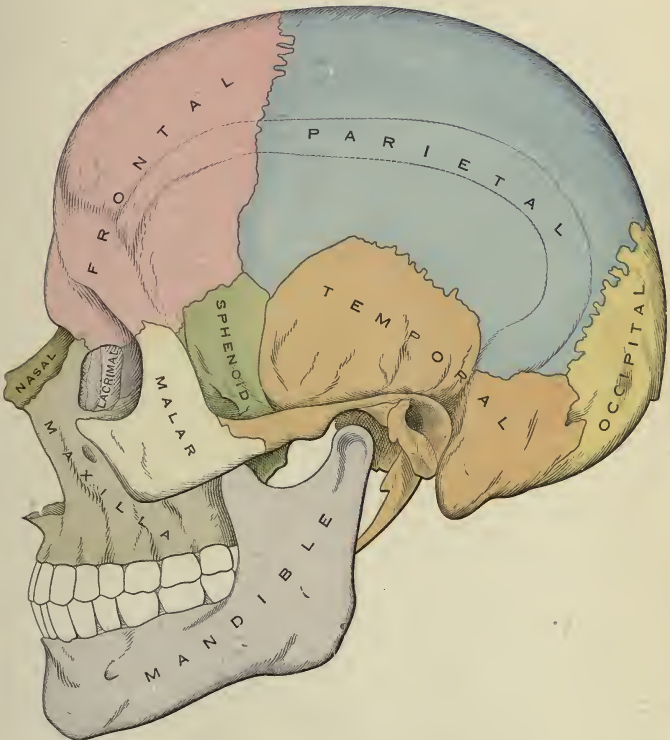
The anterior fontanelle is the largest and is situated at the junction of the sagittal, coronal, and interfrontal sutures; it is lozenge-shaped and measures

PLATE I



Anterior Aspect of the Skull.

PLATE II



Lateral Aspect of the Skull.

about $1\frac{1}{2}$ inches from before backward and 1 inch from side to side. Pulsation can be felt over this fontanelle up until the twelfth to twenty-fourth month. It usually disappears by ossification after the second year, but cases have been reported when it persists throughout life.

The posterior fontanelle is triangular in form and is situated at the junction of the superior angles of the parietal bones with the occipital bone. The lateral fontanelles are irregular in shape, and are located at the antero-inferior and postero-inferior angles of the parietal bones respectively. The posterior and lateral fontanelles close shortly after birth. The lack of ossification in the bones of the skull favors the overlapping of the bones or moulding of the infant's head during parturition, thus facilitating delivery and preventing injury to the mother and child; of course, barring some abnormal condition at the time of birth.

In adults the skull bones are closely fitted by uneven edges, there being interposed a little fibrous tissue continuous with the periosteum, the dentations are confined to the external table, the edges of the inner table lying in apposition. The lower jaw has a movable articulation differing from the others.

The bones forming the vertex or superior surfaces of the skull are: frontal, two parietal, two temporal (squamous and mastoid portions), and great wing of the sphenoid.

The Orbital Fossæ or Orbits.—These are pyramidal in shape, with their bases turned forward and outward. They are just below the supraorbital arches; their inner walls are nearly parallel and the outer walls diverge at slight right angles to each other. Each is formed by seven bones or eleven for the two orbits—the frontal, sphenoid, ethmoid, lacrymal, palate, malar, maxilla. The roof of each is formed by the orbital plate of the frontal and small wing of the sphenoid; the floor, by the malar, maxilla, and orbital

plate of the palate; inner wall, by the nasal process of the maxilla, lacrymal, ethmoid, and body of the sphenoid; outer wall, by the malar and frontal and great wing of the sphenoid.

The Nasal Fossa or Cavities.—These are placed one on each side of a median vertical wall. They open in front by the anterior nasal aperture (nares) and behind by the posterior nares. They communicate with the sinuses (air spaces) of the frontal, sphenoid, and antrum of Highmore, the latter is in the body of the maxilla, and the ethmoidal cells. Thus the danger from infection entering these air spaces following an abscess formation, influenza, etc., may readily be understood.

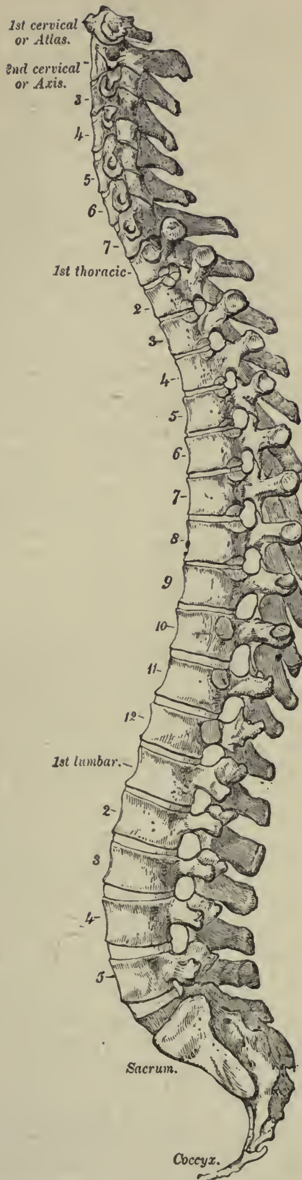
THE VERTEBRAL COLUMN AS A WHOLE

The **vertebral** or **spinal column** is a central axis upon which other parts are arranged, situated in the median line at the posterior part of the trunk; above it supports the head, by having the first vertebra receive the condyles of the occipital bone; laterally, the ribs, and it rests on the sacrum. It is made up of thirty-three separate vertebræ, imposed one upon the other with an intervertebral layers of cartilages between each one, and held in firm relationship by means of ligaments.

The vertebræ are divisible into seven **cervical,** twelve **thoracic,** five **lumbar,** five **sacral,** and four **coccygeal.** The cervical, thoracic, and lumbar vertebræ remain separate throughout life, and are known as **true** or **movable** vertebræ; but the sacral and coccygeal vertebræ are firmly united in the adult, so as to form two bones—five entering into the formation of the **sacrum** and four into the terminal bone of the spine or the **coccyx.** The sacral and coccygeal vertebræ are called the **immovable** vertebræ.

The average length of the vertebral column is about

Fig. 35



Lateral view of the vertebral column. (Gray.)

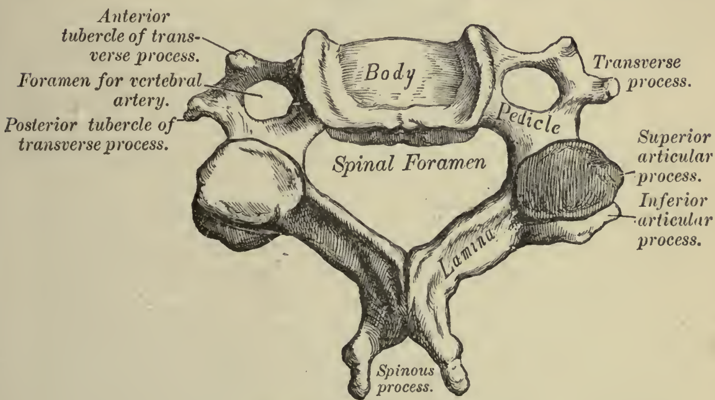
twenty-six to twenty-seven inches measured along the curved anterior surface of the column. The cervical part measures about five, the thoracic about eleven or twelve, the lumbar about seven inches, and the sacrum and coccyx the remainder.

Viewed from the side it presents several curves. The cervical curve commences at the odontoid process of the second vertebra, and ends at the middle of the second thoracic; it is convex in front, but not as marked as the other curves. The thoracic curve is concave forward, commences at the middle of the second thoracic, and ends at the middle of the twelfth thoracic. The lumbar curve, commences at the middle of the twelfth thoracic and ends at the sacrovertebral angle (about the junction of the sacrum with the fifth lumbar vertebra). It is convex in front; the convexity being more marked in the lower three lumbar vertebræ. These curves and convexities are formed by the bodies of the vertebræ. While the posterior aspect is formed by the extending spinous processes which usually can be felt underneath the skin and fascia, no matter how stout the individual. Laterally the column presents the transverse processes. The spinal cord, membranes, origin of spinal nerves, and blood-supply are within the spinal canal—formed by the intervertebral fibrocartilage, body, and arched lamina of the vertebræ; the latter fusing posteriorly, complete its boundaries. Posteriorly, the spinous processes occupy the median line, in a depression known as the vertebral groove running along the middle of the back. In the cervical region the processes are short and bifid, sloping backward and a little downward. The seventh cervical is the most prominent and can always be seen and felt beneath the skin, therefore its name—**vertebra prominens.** The thoracic processes are oblique above, more oblique in the middle, and below are nearly horizontal; in the lumbar region they are horizontal. The transverse processes of the atlas are

long; of the axis, short; then extending in size until the first thoracic is reached, thence diminishing to the last dorsal, and becoming suddenly much longer in the lumbar region.

The intervertebral foramina are always in front of the articular processes excepting those of the atlas and the upper ones of the axis. They are named from the upper of the two vertebræ which go to form them, excepting in the cervical region, where there are eight, the fissure between the skull and atlas being called the first. The spinal canal is narrowest in those portions having the least motion, viz., the dorsal and sacral regions. It is round and $\frac{3}{5}$ of an inch in diameter in the dorsal region; it is triangular, with the apex behind, in the cervical and lumbar regions; and largest of all in the cervical region. The cervical vertebræ each have a foramen (costotransverse) in their two transverse processes for the vertebral artery.

FIG. 36

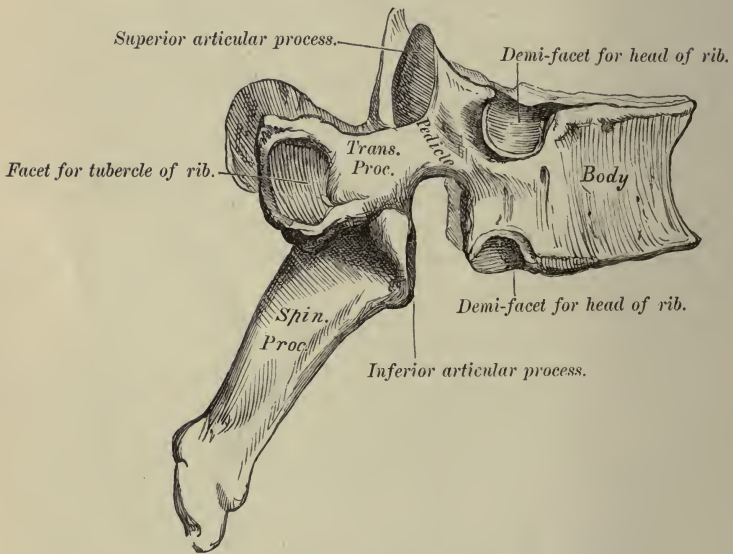


A cervical vertebra. (Gray.)

General Characteristics of a Vertebra.—A typical vertebra is made up of two parts, an anterior solid

portion, and a posterior portion, the **arch** or **neural canal.** The arch is formed by two pedicles, and two **laminæ,** supporting seven processes—viz., four **articular,** two **transverse,** and one **spinous.** Taking a typical vertebra—the tenth thoracic, for example. The body is cylindric; the upper and lower surfaces are flat, with a rim around the circumference. The front

Fig. 37

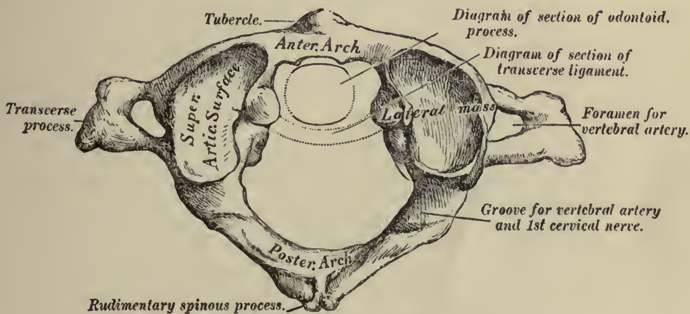


A dorsal vertebra. (Gray.)

and sides are convex from side to side and concave from above downward. The back is slightly concave from side to side. The neural arch is completed laterally by two processes of bone arising from the postero-external aspect of the body, called pedicles, and the latter continue—as lamina—behind, where they meet to complete the posterior aspect of the neural arch. The upper and lower borders of the pedicles

form intervertebral notches, which complete, with the neighboring pedicle of the vertebra, intervertebral foramina. The spinous process projects backward from the junction of the two laminæ. The transverse processes, one on either side, project outward from the arch at the junction of the pedicle with the lamina. The articular processes, two superior and two inferior, extend upward and downward respectively at the point of origin of the transverse processes.

Fig. 38

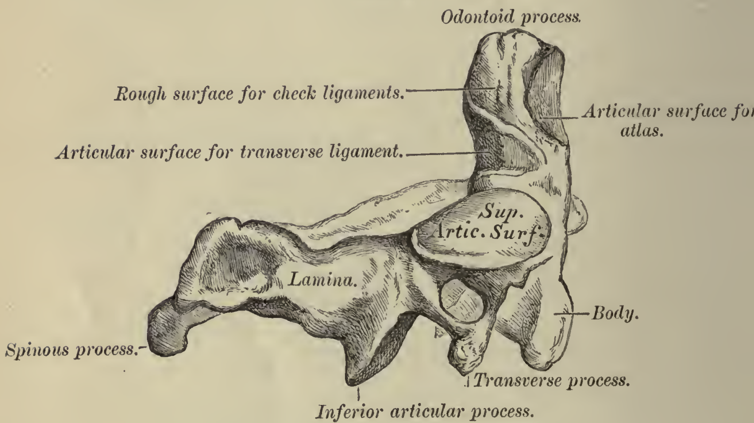


First cervical vertebra or atlas. (Gray.)

The Atlas (First Cervical Vertebra).—This, sometimes called rotation vertebra, has no body or spinous process, but is a large ring with articular and transverse processes. The posterior part of the ring or arch corresponds to the neural canal of the other vertebræ; the anterior part is occupied by the odontoid process of the axis (second cervical vertebra). This first vertebra and its relation with the odontoid process of the axis, below, and its superior articular surface receiving the condyles of the occipital bone, held in position by ligaments, permits the head to rotate and bend forward and backward, as in turning the head from side to side, and in nodding. The odontoid process of the axis is held in position by a transverse

ligament passing posterior to it and attached to the tubercle on the the inner surface of the lateral mass on either side of the arch, and by check ligaments extending from the apex of the odontoid process to the occipital bone. The atlas has a foramen (the costo-transverse) for the vertebral artery in its transverse process.

Fig. 39



Second cervical vertebra or axis. (Gray.)

The Axis (Second Vertebra).—This possesses a strong, prominent process, tooth-like in form, which arises perpendicularly from the upper surface of the body. The body in front overlaps the vertebra below. The tip of the odontoid process affords attachment to the check ligaments (see Fig. 52, page 109) and has an articular surface anteriorly, which articulates with the atlas, and an articular facet behind for the transverse ligament, which holds it firmly in position. The pedicles and laminæ form the neural arch in the same manner as the atlas and other vertebræ. The spinous process is larger than the one of the atlas. The transverse processes are small, and are perforated by the foramen for the vertebral artery.

The Sacrum and Coccyx.—The sacrum and coccyx are the result of the fusing of the lower nine vertebræ into two bones, five to form the sacrum and four the coccyx.

The **sacrum** is much larger than the coccyx, is located between the two iliac bones, articulating above with the fifth lumbar vertebra, below with the coccyx, and is perforated with foramina which transmit the spinal nerves.

The **coccyx** is pyramidal. Its vertebræ are very rudimentary, and it possesses a trace of the neural arch and transverse processes of the typical vertebra.

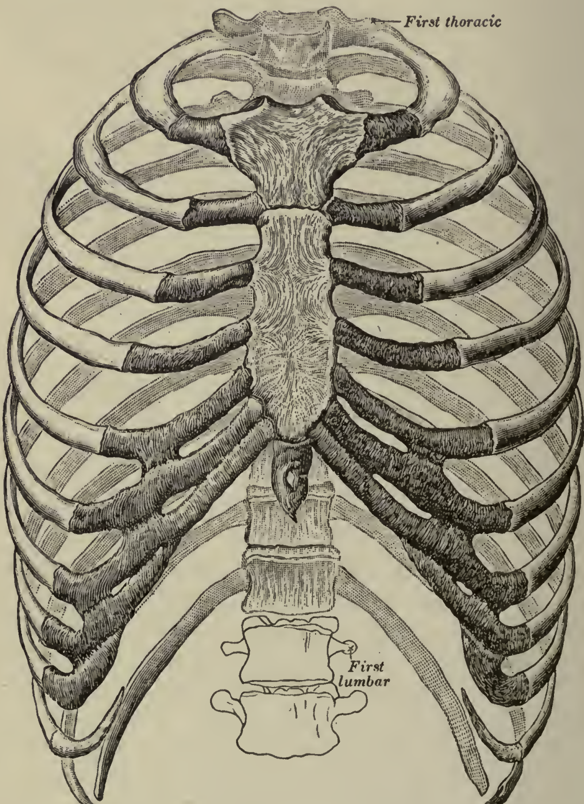
THE THORAX AS A WHOLE

The thorax is an osseocartilaginous cage, conical and flattened from before backward. The short anteroposterior diameter is characteristic of man, but in the lower mammals and human fetus it is longer than the transverse diameter. The **posterior** surface is convex forward, formed by the twelve thoracic vertebræ and back part of ribs; on either side the sulcus pulmonalis is formed by the ribs as they project backward, so that the weight of the body is more equally distributed around the vertebral column. The **anterior surface** is flattened and slightly convex, is formed by the sternum and costal cartilages, and lies at an angle of 20 or 25 degrees with the posterior. A horizontal anteroposterior diameter taken from the base of the ensiform is 8 inches (20 cm.); the transverse at the eighth or ninth ribs is 11 inches (28 cm.); the vertical anteriorly is 6 inches (15.5 cm.); and posteriorly is 12 inches (31.5 cm.). The **lateral surfaces** are convex; formed by the ribs, separated from each other by the spaces (intercostal).

The **superior** or **upper opening** of the thorax, the **inlet,** is reniform in shape, being broader from side to side

than before backward. It is bounded behind by the first thoracic vertebra; in front, by the upper border of the sternum, and on either side by the first rib.

Fig. 40



The thorax. Ventral view. (Gray.)

It slopes downward and forward so that the anterfor boundary is on a lower level than the posterior. The anteroposterior diameter is about 2 inches (5 cm.),

and the transverse about 4 inches (10 cm.). The parts which pass through the upper opening are, from before backward in or near the middle line—the sternohyoid and sternothyroid muscles, the remains of the thymus gland, the trachea (windpipe), the esophagus (gullet), thoracic duct, inferior thyroid veins, longus colli muscle of each side, bloodvessels and nerves.

The **inferior** or **lower opening** is formed by the twelfth thoracic vertebra behind, by the twelfth ribs at the sides, and in front by the eleventh, tenth, ninth, eighth, and seventh costal cartilages, which ascend on either side to form the **subcostal angle**, from the apex of which the ensiform cartilage projects. The lower opening is wider transversely than from before backward. It slopes obliquely downward and backward, so that the cavity of the thorax is much deeper behind than in front. The diaphragm closes in the opening forming the floor of the thorax, and has passing through it the inferior vena cava, the esophagus, and vagi nerves, the aorta, thoracic duct, vena azygos major, and sometimes splanchnic nerves.

The thorax contains the lungs and their pleuræ, the heart and its pericardium, the aorta and branches, and the structures mentioned under the upper opening, which pass through it.

The female thorax differs from the male as follows: general capacity is less, sternum is shorter, the upper margin of the sternum is on a level with the lower part of the body of the third thoracic vertebra (in the male it is the body of the second thoracic vertebra), the upper ribs are more movable, and thus allow a greater expansion of the upper part of the thorax than in the male (Gray).

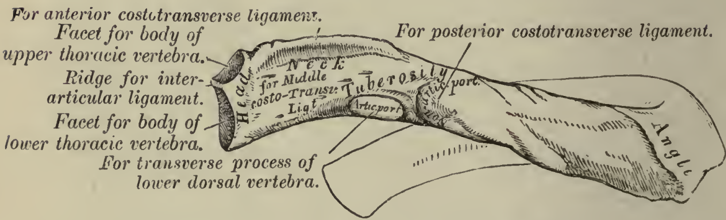
The Sternum or Breast Bone.—This is a flat, narrow bone, situated in the median line of the front of the chest, and in the adult consists of three portions. It is likened to an ancient sword; the upper piece,

representing the handle, is called the **manubrium**; the middle and larger portion, which resembles the blade, is the **gladiolus**; and the inferior piece, which resembles the point of the sword, is called the **ensiform.**

The Ribs (Costæ).—There are twelve pairs, one on each side. They are obliquely placed, running forward and downward. The obliquity increases from above downward to the ninth rib, when it reaches the maximum; from this point downward it decreases.

The first seven pairs, attached by costal cartilages to the sternum, are called **sternal, true,** or **vertebrosternal ribs,** the remaining lower five pairs are **asternal** or **false ribs;** each of the upper three pairs of false ribs has its cartilage attached to the cartilage above it, and are called **vertebrochondral** ribs; the last two pairs are attached to the vertebra behind and their anterior extremity is free; they are called **floating** or **vertebral ribs.**

Fig. 41



Vertebral extremity of a rib; external surface. (Gray.)

A Typical Rib.—Each rib has an **anterior** and **posterior** extremity. The **anterior** extremity is hollowed into a pit for union with the costal cartilage. The **posterior** extremity is divided into a **head**, a **neck**, and a **tuberosity.** The **head** has an upper and lower articular facet for articulation with the two vertebræ, above and below; and between the two facets a ridge for the attachment of the interarticular ligament.

The first rib is the shortest, most curved, and the broadest, the eighth the longest, after which they decrease in length to the twelfth; the twelfth is the narrowest.

The Peculiar Ribs.—The **first rib** is short, curved, and not twisted. Its surfaces look upward and downward. Head is small; neck is slender and rounded; angle coincides with the tuberosity, which is strong and placed on the outer margin of the rib. The upper surface presents close in front of the tuberosity a rough impression for the scalenus medius muscle, and in front of the latter two smooth impressions with an intervening ridge; the posterior impression lodges the third portion of the subclavian artery, the ridge affords attachment to the scalenus anticus muscle, and the anterior impression receives the subclavian vein.

The **second rib** is not twisted and has no angle; it presents near its middle an impression for the scalenus posticus muscle and two serrations of the serratus magnus.

The **tenth rib** has but one articular facet, usually. The **eleventh** and **twelfth ribs** are short, have single articular facets, and only slight elevations to mark the tuberosities which do not articulate with the transverse processes of the vertebræ. They are pointed anteriorly. The eleventh has a slight subcostal groove; the twelfth has no angle.

There may be thirteen ribs. The twelfth rib measures from 1 to 8 inches.

The Costal Cartilages.—These prolong the ribs to the sternum and increase the elasticity of the thorax. They consist of white hyaline cartilage. The first seven pair connect the ribs and sternum, the next three pair with the lower border of the cartilage of the preceding rib. The cartilages of the last two ribs (floating) have pointed extremities which terminate in free ends. They increase in length from the first to the seventh, then gradually diminish to the last.

They have an anterior and posterior surface, and a superior and inferior border. Their articulations with the sternum and ribs are fixed by attached ligaments.

THE BONES OF THE UPPER EXTREMITY

Upper limb	Shoulder girdle	Clavicle (collar bone). Scapula (shoulder blade).
	Arm (brachium, humerus (arm bone).	
	Forearm (antebrachium, radius, ulna (forearm bones).	
	Hand (manus)	Carpus (wrist bones). Metacarpus (bones of palm). Phalanges or bones of digits (fingers).

The Clavicle.—This bone forms the anterior portion of the shoulder girdle. It is a long, thin bone, curved somewhat like the letter *f*, and placed nearly horizontally at the upper and anterior part of the chest, immediately over the first rib. Its inner or sternal end articulates with the upper border of the sternum, and its outer or acromial end unites with the acromion process of the scapula; the two together connect the upper limb with the trunk by means of ligaments.

The Scapula (**Shoulder-blade**).—This is a large, flat bone, situated at the back and outer aspect of the chest, between the second and seventh ribs. Its posterior border is about 1 inch from and parallel with the vertebral spines. It is attached to the trunk by the clavicle, fascia, and muscles; and from it is suspended the humerus by means of the capsular ligament of the shoulder-joint, which is attached to the margins of the glenoid cavity and the head of the humerus.

This bone consists of a large, flattened, triangular body, two processes, the coracoid, and spine, which ends in the acromial process, and at the apex a cavity —glenoid, for articulation with the head of the humerus.

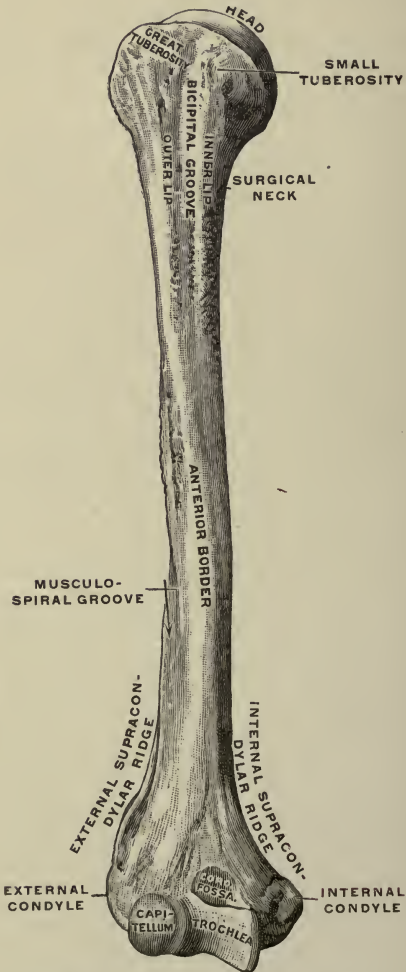
The Humerus (Arm Bone).—This bone extends from the shoulder to the elbow. It is divided into a shaft, and an upper and lower extremity.

The Upper Extremity.—This includes the head, a neck, greater and lesser tuberosities. The **head** is directed upward and slightly backward, and makes an angle of 140 degrees with the shaft. The head is round and articulates with the glenoid cavity of the scapula, being held in apposition by the ligaments of the shoulder-joint. Below the head is a depression passing around the bone called the **anatomical neck.** The **great tuberosity** is an eminence of bone situated on the outer and anterior aspect of the bone below the anatomical neck. It gives attachment to the supra- and infraspinatus and teres minor muscles, which turn or rotate the shoulder-joint and arm outward. Lying internal to the great tuberosity is the **bicipital groove,** which lodges the tendon of the long head of the biceps muscle. Internal to the groove is another smaller eminence called the **lesser tuberosity**; it receives the tendon of the subscapularis muscle, which rotates or turns the shoulder-joint inward.

The Shaft.—This is cylindrical below the tuberosities (and is known as the **surgical neck**) and triangular below this portion. It is divided into external, internal, and posterior surfaces by anterior and lateral borders. On the outer border, near the middle, is a rough surface of bone called the deltoid eminence; it affords attachment to the deltoid muscle. The middle of the inner border receives the coracobrachialis muscle; the lower three-fourths of the anterior aspect of the shaft is covered by the origin of the brachialis anticus muscle. The inner and outer borders become sharp at the lower third, and are called the supracondylar ridges. The posterior surface of the shaft is twisted so that the upper part looks inward, its lower part backward and outward. Its entire surface is almost entirely covered by the origin of the inner and outer

heads of the triceps muscle, except a portion of bone in the internal aspect of the surgical neck, and a narrow,

Fig. 42



The right humerus, front view. (Testut.)

groove passing obliquely from within downward and outward between the two portions of this muscle, which is called the **musculospiral groove** and lodges the musculospiral nerve and superior profunda artery.

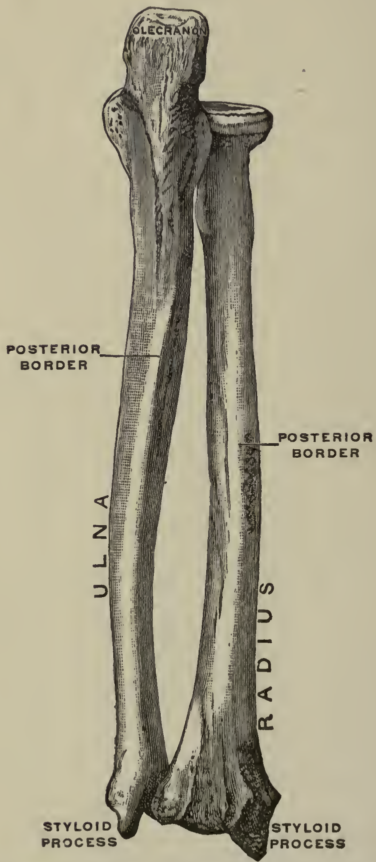
The Lower Extremity.—This is divided into an internal and external condyle, an articular surface subdivided into the **trochlea** and **capitellum.** The condyles are rounded eminences of bone extending out beyond the borders of the bone and can be always felt just beneath the skin. Between the two condyles is seen the articular facets, the outer—the capitellum—is round and smooth and articulates with the cup-shaped surface of the head of the radius; the inner—the **trochlea**—presents a deep depression between two well-marked borders and articulates with the sigmoid cavity of the ulna. These articular surfaces mentioned enter into the formation of the elbow-joint, and are held in position by the capsular and internal and external lateral ligaments of the elbow-joint. Above and in front of the articular surface (trochlea) is a depression called the **coronoid fossa,** which receives the coronoid process of the ulna when the arm is flexed; above and behind the trochlear surface is a deep, triangular depression, called the **olecranon fossa,** which receives the olecranon process of the ulna when the forearm is extended.

The Bones of the Forearm.—The Ulna.—This is the internal of the two bones of the forearm. It articulates above with the humerus, externally with the radius, and below the triangular fibrocartilage at the wrist. It presents an upper and a lower extremity and a shaft.

THE UPPER EXTREMITY.—It is divided into an olecranon process, a coronoid process, and greater and lesser sigmoid cavities. The **olecranon process** forms the uppermost part of the ulna. It terminates superiorly in front in a peak of bone, which overhangs the greater sigmoid cavity; behind this is a rectangular,

thickened tuberosity, which forms the point of the elbow, and can be felt just beneath the skin. The

Fig. 43



The bones of the right forearm, rear view. (Testut.)

posterior surface of the olecranon is triangular and becomes narrowed below and extends into the posterior border of the ulna. The anterior surface is concave

and smooth, and forms the upper part of the greater sigmoid cavity. The inferior surface is smooth and attached to the shaft. The greater sigmoid cavity articulates with the trochlear surface of the humerus. The **coronoid process** is less marked than the olecranon process; it is smooth, concave, and forms the base of the greater sigmoid cavity.

The **lesser sigmoid cavity** is seen at the outer margin of the greater cavity, with which it is continuous; it is concave from before backward; and articulates with the head of the radius held in position by the orbicular ligament.

The Shaft.—The shaft tapers from above, is three-sided in its upper three-fourths, slender and cylindrical in its lower fourth. It presents anterior, posterior, and internal surfaces, and anterior, posterior, and external borders.

The Lower Extremity.—This presents a rounded head; from its inner and back part the styloid process projects downward, giving attachments to the internal lateral ligament and the triangular fibrocartilage of the wrist-joint. The **head** of the lower extremity has an inferior articular surface, upon which the triangular fibrocartilage plays, and an outer, narrow one, convex for the sigmoid cavity of the radius. The styloid process of the ulna can always be felt beneath the skin. The inner border of the ulna has attached to its length the interosseous membrane, a ligamentous septum stretching to the radius.

The Radius.—It lies to the outer side of the forearm alongside of the ulna. It is a long bone, and articulates above with the capitellum of the humerus, the ulna, internally; the scaphoid and semilunar bones of the wrist, inferiorly. It presents for examination a shaft and an upper and lower extremity.

The Upper Extremity or Head.—It is disk-shaped, convex in circumference, and its upper surface has a depression for the capitellum of the humerus,

with which it articulates. It also internally rotates within the lesser sigmoid cavity of the ulna. Below the head is the **neck**, which is round and smooth, and affords attachment to the supinator brevis muscle.

THE SHAFT.—It is larger below than above, slightly curved, and convex outward and backward. Below the neck on the inner aspect is an elevation of bone called the **bicipital tuberosity**, which receives the tendon of the biceps muscle. Below this tuberosity the shaft has three surfaces and three borders.

THE LOWER EXTREMITY.—On the inner side of the lower extremity at right angles to the inferior articular surface is a concave articular facet which articulates with the lower extremity of the ulna; the two are held together by ligaments of the inferior radio-ulnar articulation. To the smooth surface of bone between these articular surfaces is attached the interarticular fibrocartilage of the wrist-joint.

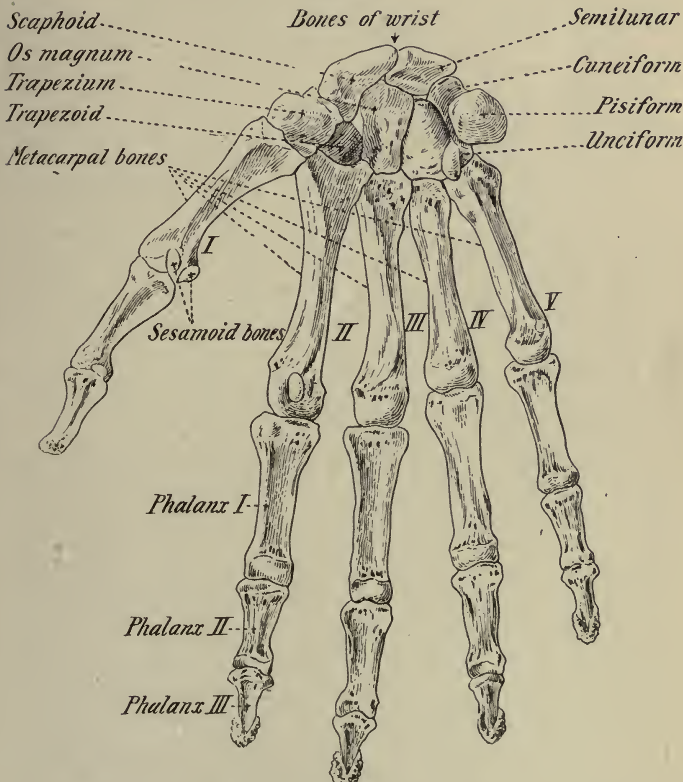
THE ARTICULATIONS OF THE CARPAL BONES

	Superior.	External.	Inferior.	Internal.	Anterior.	Posterior.	Number.
Scaphoid	Radius	Free	Trapezium trapezoid	Os magnum semilunar	Free	Free	5
Semilunar	Radius	Scaphoid	Os magnum unciform	Cuneiform	Free	Free	5
Cuneiform	Triangular fib. cart.	Semilunar	Unciform	Free	Pisiform	Free	3
Pisiform	Free	Free	Free	Free	Free	Cuneiform	1
Trapezium	Scaphoid	Free	First metacarpal	Trapezoid second metacarpal	Free	Free	4
Trapezoid	Scaphoid	Trapezium	Second metacarpal	Os magnum	Free	Free	4
Os magnum	Scaphoid lunar	Trapezoid	Second, third, and fourth metacarpals	Unciform	Free	Free	7
Unciform	Lunar	Os magnum	Third and fourth metacarpals	Cuneiform	Free	Free	5

The Bones of the Wrist (Carpus).—The bones of the wrist, eight in number, are arranged in two rows. Those of the upper row, enumerated from the

radial (outer side) to the ulnar (inner side), are: the **scaphoid, semilunar, cuneiform,** and **pisiform**; those of the lower row, enumerated in the same order, are:

FIG. 44



Bones of the hand.

the **trapezium, trapezoid, os magnum,** and **unciform.** Each bone presents six surfaces—superior, inferior, anterior, posterior, internal, and external. The anterior and posterior are rough for the attachment of ligaments.

The Metacarpal Bones or Bones of the Palm.—The **metacarpal bones** are five in number, from 1 to 5, the first being the metacarpal bone of the thumb, the fifth the metacarpal bone of the little finger. They are long, cylindrical bones presenting a shaft, and an upper and lower extremity.

Articulations of Metacarpal Bones.—

First bone (proximal extremity) trapezium.	
Second bone (proximal extremity)	Trapezium, trapezoid, os magnum. Third metacarpal bones.
Third bone (proximal extremity)	Os magnum, second and fourth metacarpal bones.
Fourth bone (proximal extremity)	Os magnum, unciform, third and fifth metacarpal bones.
Fifth bone (proximal extremity)	Unciform and fourth metacarpal bones.

The **distal extremity** of each metacarpal bone articulates with the corresponding proximal extremity of the first phalanx below.

The Phalanges of the Hand (Four Fingers, One Thumb).—The phalanges are fourteen in number, three for each finger and two for the thumb. They consist of a shaft and upper and lower extremity. They are similar in shape to the metacarpal bones, only smaller, and are held together by ligaments, reinforced by the fibrous sheaths of the flexor and extensor tendons. The first bone articulates with its metacarpal bone above, and the second phalanx below; the second with the first or proximal phalanx above and the third or distal phalanx below; and the third phalanx with the second phalanx above. Of course, the first phalanx of the thumb articulates with the metacarpal bone above and the second phalanx below; the second phalanx articulates with the first phalanx above; there being no third phalanx.

All the long bones described have a **nutrient canal** for the entrance of the **nutrient artery**.

THE BONES OF THE LOWER EXTREMITY

Lower limb	Pelvis	Ossa innominate (with sacrum and coccyx)
	Thigh	Femur
	Leg	Tibia Fibula
	Foot	Tarsus Metatarsus Phalanges (toes)

The Bones of the Pelvis.—The Os Innominatum (Hip Bone).—This is so named from its bearing no resemblance to any known object. There is one on either side. It is irregular in shape, twisted, flat above, expanded below, and constricted in the centre. With its fellow of the opposite side it forms the lateral and anterior walls of the pelvic cavity, which is completed behind by the sacrum. In young subjects it consists of three separate parts that meet to form the large bone, and for purposes of description is divided into the **ilium, ischium,** and **pubis.**

The **ilium** is the upper expanded portion and forms less than two-thirds of the acetabulum (this is the cavity which receives the head of the thigh bone).

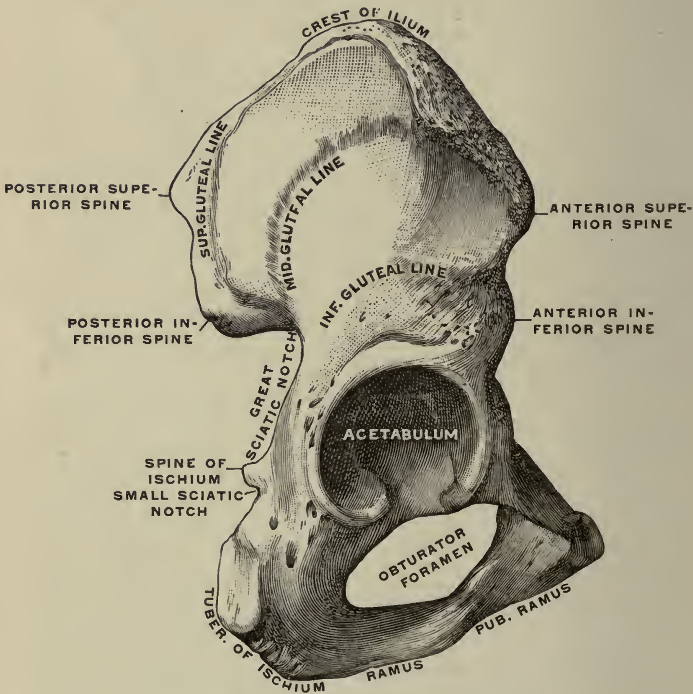
The **os pubis** forms with its fellow of the opposite side the anterior wall of the pelvic cavity, and bounds the thyroid or obturator foramen above and partly in front. It consists of a body and two rami; at the inner extremity of the body is a roughened surface, oval in shape for articulation with the opposite bone; when the two bodies articulate they form the **symphysis pubis.** The ascending and descending rami pass upward and downward respectively from the body.

The **ischium** forms the lower and back part of the hip bone, bounds the thyroid foramen below, and forms over two-fifths of the acetabulum. It presents a body, a ramus, and a tuberosity.

The Pelvis as a Whole.—The pelvis (basin) is composed of four bones: two ossa innominata (innominate

bones) on either side and in front and the sacrum and coccyx behind. It is divided by an oblique line passing through the prominence of the sacrum behind, and the iliopectineal line and symphysis pubis in front, into a **false** and **true pelvis.**

Fig. 45

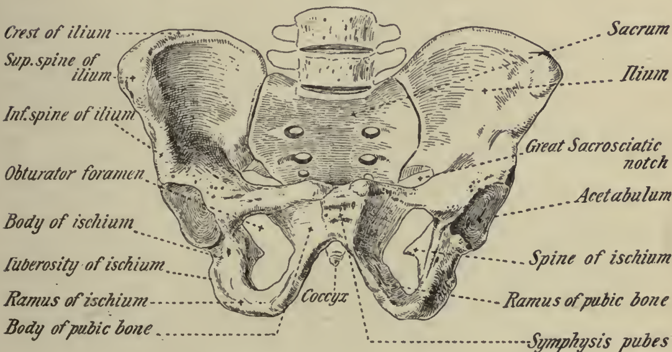


The right hip bone; outer surface. (Testut.)

The False Pelvis.—This is the expanded portion of the pelvic cavity above this plane. It is bounded on each side by the iliac fossæ of the iliac bones; in front it is incomplete; the space of the basin between the anterior superior spines is completed by the abdominal wall; behind is a deep notch.

THE TRUE PELVIS.—This is the real bony basin, situated below the oblique plane which divides the prominence of the sacrum, iliopectineal line, and symphysis pubis. It is smaller than the false pelvis. For description it presents a **superior circumference** or **inlet,** an **inferior circumference** or **outlet,** and a **cavity.** The **superior circumference** forms the brim of the pelvis, the heart-shaped space being called the **inlet.**

FIG. 46



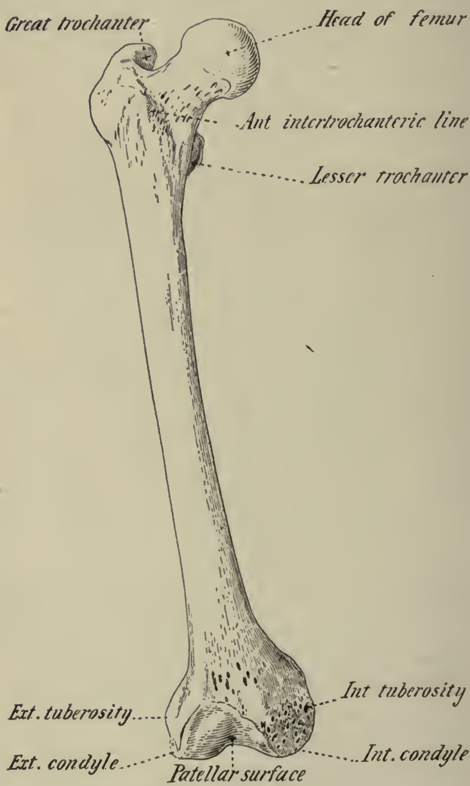
Male pelvis from in front and below.

The **cavity** of the true pelvis is bounded in front by the symphysis pubis; behind by the concavity of the sacrum and coccyx, which, curving forward above and below, contracts the inlet and outlet of the canal; laterally it is bounded by the inner surface of the ischium and that part of the ilium which is below the iliopectineal line. It is shallow in front, measuring $1\frac{1}{2}$ inches in depth at the symphysis, $3\frac{1}{2}$ inches in the middle, and $4\frac{1}{2}$ inches posteriorly.

The **lower circumference** or **outlet** is irregular in shape. Bounded by three eminences the point of the coccyx behind, and the tuberosities of the ischia on either side. The eminences are separated by three notches: one in

front, the **pubic arch** formed by the rami of the ischia and pubes, and the symphyses. The other notches, one on each side, are formed by the sacrum and coccyx

Fig. 47



Right thigh bone, femur.

behind, the ischium in front, and the ilium above; the latter notches are called the sacrosciatic notches; in the recent state they are converted into foramina by the lesser and greater sacrosciatic ligaments. When the

ligaments are present, as in life, the real boundaries of the outlet are the subpubic ligament and the rami of the os pubis and ischium in front, the great sacrosciatic ligaments and the tip of the coccyx behind, and the tuberosities of the ischia on each side.

The Femur.—The **femur** (thigh bone) is the largest, longest, and strongest bone of the skeleton. It is convex in front and concave behind, and when the body is erect the femur is inclined inward and slightly backward. It is divisible into an upper and lower extremity and a shaft.

The Upper Extremity.—This presents a **head**, a **neck**, and a **great** and **small trochanter**. The **head** is joined to the shaft by the neck, it is round and forms more than a half sphere. It articulates with the acetabulum of the innominate bone. Just below and behind the centre of the head is a depression for the interarticular or round ligament of the hip-joint, which is attached by its upper end to the centre of the acetabulum. The **neck** is narrow just at the junction of the head, constricted in the centre, and widens as the base is approached; is flattened slightly anteriorly and posteriorly, concave above and below. The direction of the neck is slightly upward, forward, and inward, being set upon the shaft at an angle of 125 degrees. The junction of the neck with the shaft shows in front and behind a slight elevation or roughened surface of bone called the anterior and posterior intertrochanteric lines, and they afford attachment to the capsular ligament and ligament of Bigelow. The posterior intertrochanteric line in the middle receives the quadratus femoris. The small **trochanter** is a small projection of the bone seen at the inferior aspect of the base of the neck when it unites with the shaft. The **great trochanter** is a projection of bone extending upward beyond the neck. It can be felt under the skin. It is quadrilateral in shape, with its base attached to the shaft of the femur.

The Shaft.—The shaft is long and rounded in front and on the sides, is narrow in the centre, and enlarges gradually above and below, being the broadest at the lower extremity. It presents an anterior surface, which is covered by a flat, yet large muscle on its upper three-fourths — the crureus — and below this two small spaces of bone give origin to the subcrureus muscle. There are an internal and an external surface; they are covered by the crureus and vastus internus and externus respectively. The lateral surfaces are separated posteriorly by a longitudinal rough ridge of bone, about the middle of the shaft—called the **linea aspera.** It is divided into an inner and outer lip, and a middle ridge.

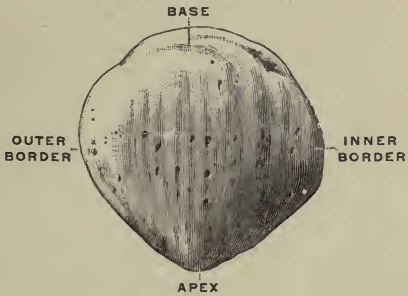
The outer and inner lips of the linea aspera at the junction of the middle with the lower third of the bone, posteriorly, separate and include between their diverging borders a triangular-shaped, smooth surface of bone, free from muscular attachments, called the **popliteal surface.** The space is crossed by the popliteal artery, vein, and the internal popliteal nerve, the artery being next to the bone.

The Lower Extremity.—This presents two condyles —**internal** and **external** and **intercondylar notch,** and an **inner** and **outer tuberosity** or **tubercle.** The condyles articulate with the upper articular facets of the upper extremity of the tibia, and in front the articulating surface is extended upon the shaft for a short space (trochlear surface), to articulate with the patella (knee-cap). The capsular ligament of the knee-joint is attached just above the condyles on the shaft of the bone. The **intercondylar space** is filled with fat and has the crucial ligaments passing from the internal surfaces of the condyles to the upper surface of the tibia. These ligaments as they cross each other form the letter X. The femur has an internal and external rounded border.

The Patella or Knee-cap.—This is a flat, triangular bone, situated at the anterior part of the knee-joint. It is usually regarded as a sesamoid bone, developed in the quadriceps extensor tendon (formed by the rectus femoris, the vastus internus and externus, and the crureus muscles).

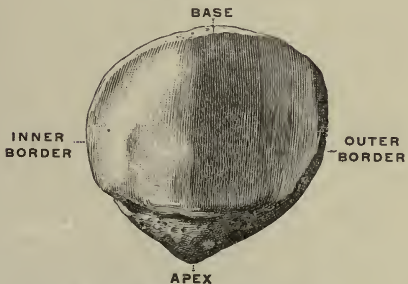
The patella can always be felt beneath the skin and fascia.

FIG. 48



The right patella, ventral surface. (Testut.)

FIG. 49



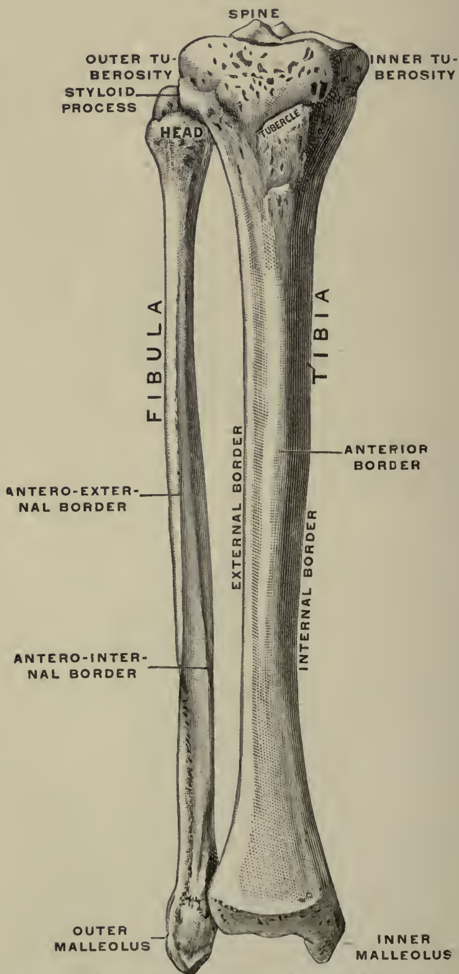
The right patella, dorsal surface. (Testut.)

Bones of the Leg.—The bones of the leg are two, the **tibia** and **fibula.**

The Tibia.—This is situated at the inner and front part of the leg. It is the longest, and largest bone

in the body, excepting the femur. In the male its direction is vertical; in the female inclined obliquely

Fig. 50



The right tibia and fibula in their normal relations, front view. (Modified from Testut.)

downward and outward slightly. To its outer side is the fibula.

The tibia presents an upper and lower extremity, and shaft.

THE UPPER EXTREMITY OR HEAD.—This is large and expanded on either side into the internal and external tuberosities. The superior surface of each tuberosity presents a concave articular surface, which receives the condyles of the femur above. The inner facet is oval, the outer circular. Posteriorly the external tuberosity presents a facet for articulation with the head of the fibula. The anterior surfaces of the tuberosities of the tibia are continuous with one another, thus forming a surface which is triangular in shape and at the lower part is the **tubercle,** which receives the ligamentum patellæ.

THE SHAFT.—The shaft of the tibia is long and triangular, broad above, gradually decreasing in size to its most slender part—the commencement of the lower fourth; it then enlarges again at its lower extremity. It presents internal, external, and posterior surfaces; internal, external, and anterior borders, the anterior border forms the shin, so-called.

THE LOWER EXTREMITY.—This, much smaller than the upper, presents five surfaces—anterior, posterior, internal, external, and inferior. The **anterior surface** is smooth and rounded above, and crossed by the extensor tendons of the toes and tibialis anticus muscle. The **external surface** is a rough, triangular depression for the attachment of the interosseous membrane above, at its lower part is a smooth hollow surface covered by cartilage, for articulation with the lower end of the fibula. The **inferior surface** is quadrilateral and articulates with the upper aspect of the astragalus, one of the tarsal bones; this surface is continuous with the articular surface of the internal malleolus. The **internal surface** is practically the **internal malleolus,** a pyramidal process of bone, flattened from without inward. The inner

surface is convex and just beneath the skin. The outer surface of the malleolus is smooth and articulates with the astragalus bone. The posterior surface is flattened and crossed by the flexor tendons of the toes and the tibialis posticus muscle.

The Fibula.—The fibula (clasp) or peroneal bone, nearly equal in length to the tibia, is the thinnest long bone in the body. It lies parallel with the tibia at the outer side of the leg. It articulates by its upper extremity with the outer tuberosity of the tibia, by its lower extremity with the astragalus. The two articulating extremities are held in place by ligaments, all entering into the formation of the superior and inferior tibiofibular articulation. The inner border has attached to it the outer edge of the interosseous membrane, stretching between the tibia and fibula. The fibula is the most irregular bone in the body as its surfaces and borders are not evenly defined.

The outer aspect of the lower extremity is subcutaneous and is grooved behind for the lodgement of the tendons of the peroneus longus and brevis muscles—the latter tendon being next to the bone. The lower extremity forms the external malleolus.

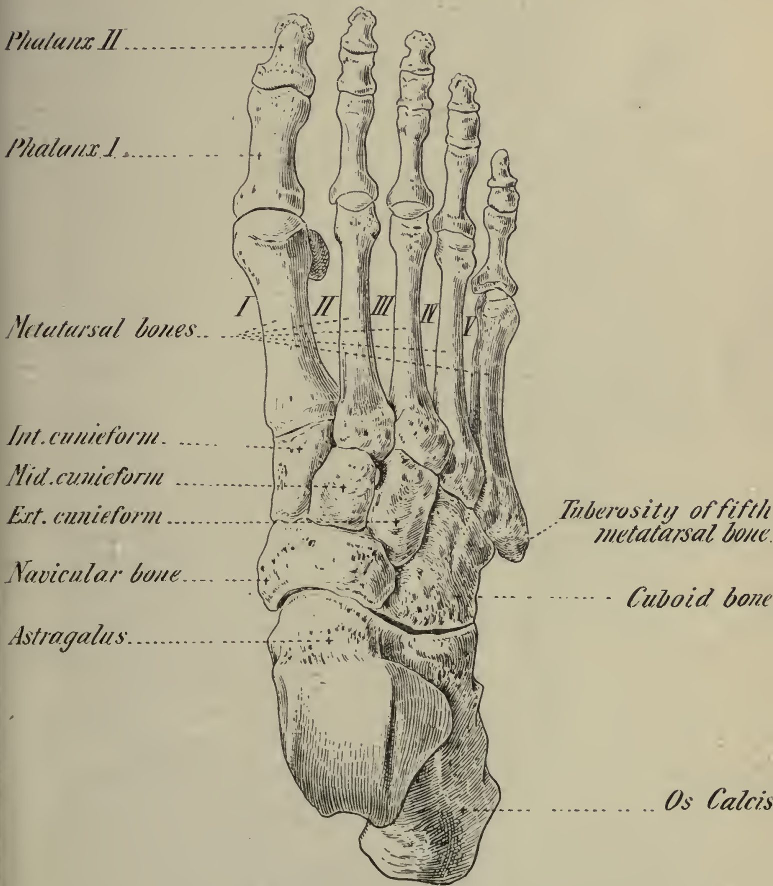
The Bones of the Foot.—The **bones of the foot** consist of three divisions—the **tarsus, metatarsus,** and **phalanges** (toes).

The Tarsus.—This consists of seven irregular-shaped bones held in position by ligaments and reinforced by the inserted sheaths of the tendons of muscles. The bones are, viz., the **os calcis** or **calcaneum, astragalus, cuboid, scaphoid, internal, middle,** and **external cuneiform.** The **os calcis** forms the heel, and is the largest of the seven bones. It articulates above, with the astragalus; in front, with the cuboid. It presents six surfaces—superior, inferior, internal, external, anterior, and posterior.

The **astragalus** or **ankle bone** (talus) receives the weight of the body from the leg. It articulates with

four bones—the tibia above and internally; the fibula externally; os calcis below, and scaphoid in front. It belongs to the irregular group of bones.

Fig. 51



Bones of the right foot.

The Metatarsal Bones.—The metatarsal bones are five in number; they articulate with the tarsal bones behind and the corresponding phalanges (1 to 5) in front. They present for examination a **shaft**, a **proximal extremity**, or a **base**; a **distal extremity** or **head.**

The first bone is the shortest and thickest, the second the largest, and the fifth the thinnest. Each bone has a nutrient canal on its plantar surface.

The Phalanges of the Foot (Bones of the Toes).—The phalanges have the same arrangement and shape as those of the fingers, except that they are longer and larger. They are fourteen in number for each foot, allowing three (1st, 2d, and 3d) for the second, third, fourth and fifth toes; the big toe has two (1st and 2d).

The first or proximal phalanges articulate with the corresponding metatarsal bone above and the second phalanges below. The second phalanges articulate with the corresponding first phalanges above and third below. The last or distal phalanges articulate with the corresponding second phalanges above.

QUESTIONS

1. How many bones enter into the formation of the body skeleton?
2. Name in a general way the bones which are included under the axial skeleton. Appendicular skeleton.
3. How many auditory ossicles are there?
4. Give the classification of bones?
5. Name the long bones. Short bones. Flat bones. Irregular bones.
6. Give an example of an articular eminence. Articular depression.
7 Name two varieties of non-articular eminences. Non-articular depressions.
8. Give the constituents of dried bone.
9. Do the mineral salts predominate in the bones of children or adults?
10. Why are the bones of children more elastic than those of adults?
11. What is the periosteum of a bone?
12. Give the two classes of bone based on their composition?
13. Wha do you understand by the medulla of a bone? Give contents.

14. Name the two varieties of marrow and what makes the difference in color?
15. Give the function of bone-marrow.
16. How are bones nourished during life?
17. Name the number of bones forming the cranium. The face.
18. Name the unpaired bones of the cranium. The paired bones.
19. Name the unpaired bones of the face. The paired.
20. Give the bones bounding the orbital cavity.
21. What bones and cartilage form the septum of the nasal cavity?
22. How many fontanelles are there in the skull of an infant?
23. Until what age do they remain membranous before ossification generally occurs?
24. How many separate vertebra are there?
25. Give the subdivisions of vertebra, as regards their location?
26. Name the movable vertebra. Immovable.
27. Mention the general characteristics of a typical vertebra.
28. Give the contents of the spinal canal.
29. Name the structures that pass through the upper opening of the thorax. The lower opening.
30. What structure separates the thoracic cavity from the abdominal cavity?
31. What openings are found in the diaphragm and what passes through each one?
32. Differentiate the female from the male thorax.
33. How many pairs of ribs are there?
34. Give the classification of ribs as to arrangement.
35. What do you understand by the true or vertebrosternal ribs? The false or asternal ribs? Vertebrochondral ribs? Floating or vertebral ribs?
36. What are the functions of the costal cartilages?
37. What bones form the shoulder girdle?
38. Name the bones of arm. Forearm. Wrist. Palm. Fingers.
39. Name the bones which form the pelvis.
40. Differentiate the true from the false pelvis.
41. Name the thigh bone. Bones of leg. Instep.
42. How many metacarpal bones are there? Phalanges?
43. What bones does the humerus articulate? The femur? The Tibia? The ulna? The radius?

CHAPTER VI

ARTICULATIONS OR JOINTS

The General Structure of Joints.—The bones of the human body are held in movable, immovable, or mixed relations with each other, depending upon the degree of action required in the various movements, functions, and positions assumed by the body. The parts entering into the formation of these relations taking place between bones, comprise a joint or articulation—they are: **bones, ligaments, cartilage,** and a **synovial membrane.**

Bones.—The articular portions of bones are enlarged to form a joint of suitable size, so that muscles passing over the joint can act at a greater angle. The layer of bone beneath the cartilage entering into a joint is a compact **articular lamella.**

Cartilage.—There are three varieties of cartilage—hyaline, fibrocartilage, and yellow elastic (see page 51 for description of cartilage). The fibrocartilage and hyalin are utilized in the structure of a joint; the former where slight movement and great strength are required—as between vertebræ and the pubic bones of the pelvis; the latter where freedom of movement is essential, and a greater surface for general convenience of mutual connection is demanded, as in the shoulder- and hip-joints, etc.

Ligaments.—The ligaments connecting the immovable joints, such as the bones of the skull, consist of a thin layer of fibrous membrane—called **sutural ligaments,** and have a layer of cartilage interposed—as the bones of the base of the skull.

The **ligaments** are mainly white fibrous tissue of various forms, serving to connect the articular surfaces of bones; and the fibers, usually arranged in parallel rows, or closely interlaced with one another, present a white, shining, silvery surface, when seen in the recent state. Some ligaments contain yellow elastic tissue, which is present in the ligamentum subflava—connecting the adjacent arches of the vertebræ in man.

The Synovial Membrane.—This is a thin, delicate serous membrane arranged like a short white tube, attached by its open ends to the margins of the articular cartilages and covering the inner surfaces of the various ligaments, so that along with the cartilage it completely encloses the joint cavity. It secretes a viscid, thick fluid like the white of an egg—hence its term **synovia**—which acts as a lubricant to the joint. The membrane is composed of a layer of endothelial cells resting upon a thin layer of fibro-elastic (subendothelial) tissue. There are three varieties of synovial membranes—**articular, bursal,** and **vaginal.**

The **articular** is found in a freely movable joint. It lines the capsule and the non-articular intracapsular portion of the bones which enter into the formation of a joint. Some of these membranes contain fat, acting as a cushion between the articular surfaces.

The **bursæ** are mucous—between the skin and bone (subcutaneous synovial bursæ); and synovial—between muscles, tendons, and bone (subtendinous synovial bursæ).

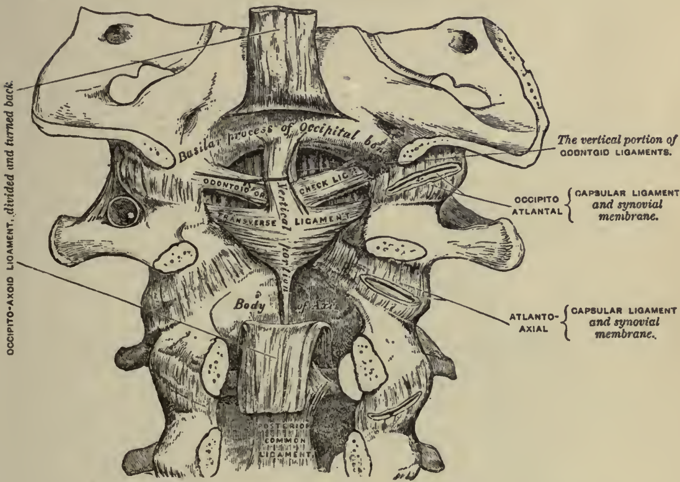
Vaginal synovial membranes are sheaths for tendons. They prevent friction and with their secretion lubricate the tendons as they move within the sheath in carrying on their action.

Some joints have tendons passing through their cavities (the knee-joint has the popliteus muscle and the shoulder-joint the biceps) and they are always enclosed by the synovial membrane within the joint, to prevent friction and facilitate action.

- *Synarthrosis* or Immovable Joint. Surfaces separated by fibrous membrane or by a line of cartilage, without any intervening synovial cavity, and immovably connected with each other. As in joints of cranium and face (except mandible).
  - *Sutura.* Articulation by processes and indentations interlocked.
    - *Sutura vera* (true) articulate by indented borders.
      - *Dentata*, having tooth-like processes. As in interparietal suture.
      - *Serrata*, having serrated edges like the teeth of a saw. As in interfrontal suture.
      - *Limbosa*, having bevelled margins and dentated processes. As in frontoparietal suture.
    - *Sutura notha* (false) articulate by rough surfaces.
      - *Squamosa*, formed by thin bevelled margins, overlapping each other. As in squamoparietal suture.
      - *Harmonia*, formed by the apposition of contiguous rough surfaces. As in intermaxillary suture.
  - *Schindylesis.*—Articulation formed by the reception of a thin plate of one bone into a fissure of another. As in articulation of rostrum of sphenoid with vomer.
  - *Gomphosis.*—Articulation formed by the insertion of a conical process into a socket—the teeth.
- *Amphiarthrosis*, Mixed Articulation.
  - *Symphysis.*—Surfaces connected by fibrocartilage. There is a partial joint cavity and may be an incomplete synovial membrane. Has limited motion. As in joints between bodies of vertebræ.
  - *Syndesmosis.*—Surfaces united by an interosseous ligament. As in the inferior tibiofibula articulation.
- *Diarthrosis*, Movable Joint.
  - *Ginglymus.*—Hinge-joint; motion limited to two directions, forward and backward. Articular surfaces fitted together so as to permit of movement in one plane. As in the interphalangeal joints and the joint between the humerus and the ulna.
  - *Trochoid or Pivot-joint.*—Articulation by a pivot process turning within a ring or ring around a pivot. As in superior radioulnar articulation and atlanto-axial joint.
  - *Condyloid.*—Ovoid head received into elliptical cavity. Movements in every direction except axial rotation. As the wrist-joint.
  - *Reciprocal Reception* (saddle-joint).—Articular surfaces inversely convex in one direction and concave in the other. Movement in every direction except axial rotation. As in the carpometacarpal joint of the thumb.
  - *Enarthrosis.*—Ball-and-socket joint; capable of motion in all directions. Articulations by a globular head received into a cup-like cavity. As in hip- and shoulder-joints.
  - *Arthrodia.*—Gliding joint; articulations by plane surfaces, which glide upon each other. As in carpal and tarsal articulations.

The Classification of Joints.—All joints of the body are classified under three main groups—**immovable articulation** (synarthrosis), **slightly movable** or **mixed articulation** (amphiarthros), **movable articulation** (diarthrosis).

FIG. 52



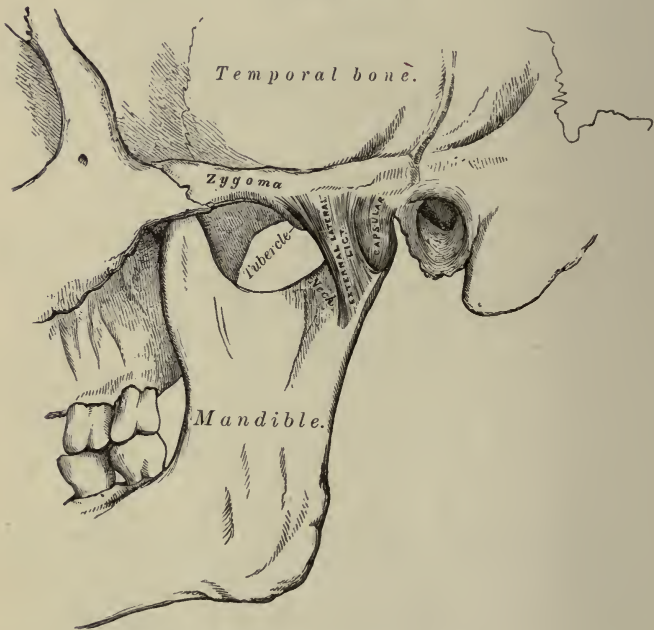
Occipito-axial and atlanto-axial ligaments. Posterior view, obtained by removing the arches of the vertebræ and the posterior part of the skull. (Gray.)

Synarthrosis or **Immovable Joint.**—Under this classification are included all the articulations in which the surfaces of the bones are in almost direct contact, being fastened together by an intervening mass of connective tissue, and in which there is no joint cavity and scarcely any motion. Examples: joints between the bones of the skull and face, excepting those of the mandible.

Amphiarthros or **Mixed Joint.**—In this variety there is only a slight amount of motion. There are two varieties—**symphysis,** as the symphysis pubes and

bodies of vertebræ in which the articulating osseous surfaces are connected by a broad flattened disk of fibrocartilage which is firmly attached to both bases in the articulation. **Syndesmosis,** in this variety there is slight motion and the bony surfaces are held in relation by an interosseous ligament. Example: inferior tibiofibular articulation (between tibia and fibula).

Fig. 53



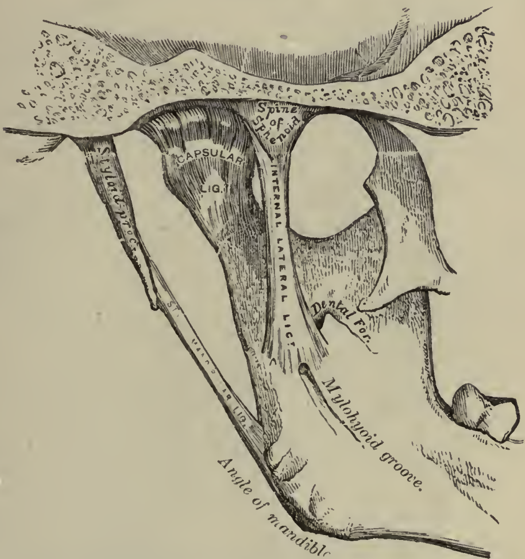
Temporomandibular articulation. (Gray.)

Diarthrosis or Movable Joint.—Under this variety are included the greater number of the joints of the body, characterized by their freedom of movement. These joints are formed by the bringing together of the articular surfaces of two bones, covered by hyaline

cartilage, and held together by ligaments with a lining synovial membrane.

The Kinds of Movement Admitted in Joints.—These are divided into **gliding, angular, circumduction,** and **rotation.** They are often combined, and it is seldom that one distinct kind of motion is seen in any certain joint.

FIG. 54

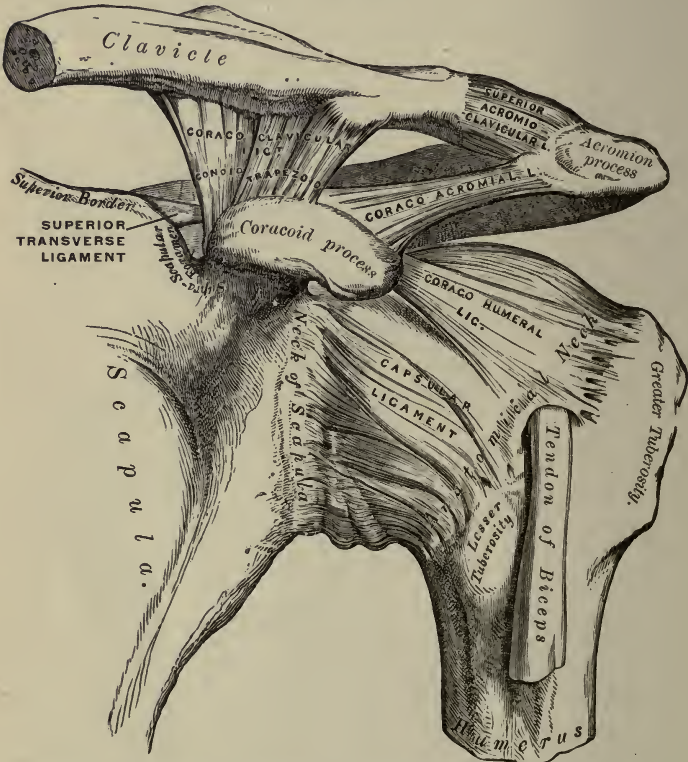


Temporomandibular articulation. Internal view. (Gray.)

Gliding Movement.—This is common to all movable joints, but in the articulations of the wrist and foot it is the only motion permitted. It consists of one surface of a bone gliding over an adjacent bone without any angular or rotatory movement. The sliding of a bone over a wide range of surface, as is seen in the patella (knee-cap) over the condyles of the femur, is called **coaptation.**

Angular Movement.—This is seen only in the joints of long bones, whereby the angle between the two bones is either increased or diminished. It is expressed in

Fig. 55

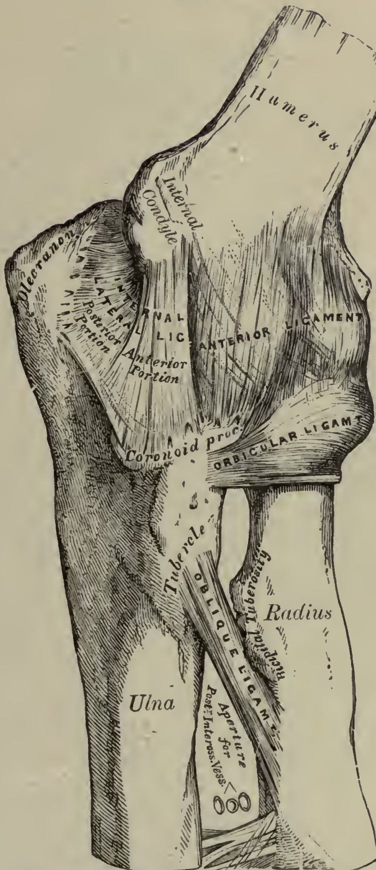


The left shoulder-joint, scapuloclavicular articulations, and proper ligaments of the scapula. (Gray.)

four ways, as follows: **bending** or **flexion**—to bend the arm or leg forward or backward, etc.; **straightening** or **extension**—to straighten the legs and thighs as in stand-

ing, the arms, fingers, etc.; **adduction**—to move a limb toward the middle line of the body or extremity;

Fig. 56

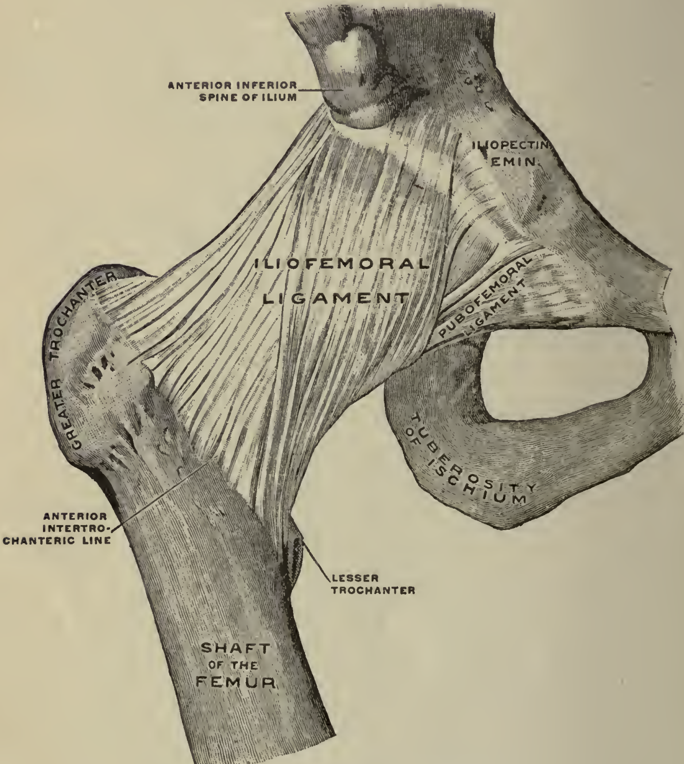


Left elbow-joint, showing anterior and internal ligaments.

abduction—to move it away from the middle line of the body or extremity. When speaking of adduction or

abduction of the fingers or toes, the second finger of the hand and second toe are taken as the middle line and not the middle of the body.

FIG. 57

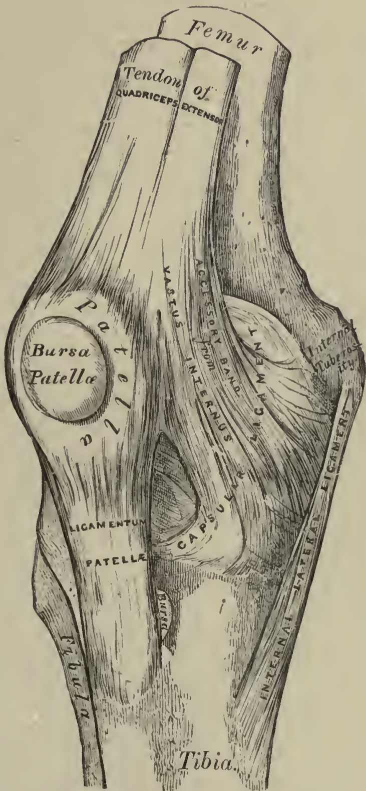


Right hip-joint, from in front. (Spalteholz.)

Circumduction.—This is the limited degree of motion which takes place between the head of a bone and its articular cavity, when the extremity is swung in such a manner that the sides and extremities of the limb circumscribe a conical space around an imaginary

axis, the base of the cone corresponding to the lower extremity of the limb and the apex to the articular cavity. This kind of movement is best seen in the shoulder- and hip-joints.

Fig. 58



Right knee-joint. Anterior view. (Gray.)

Rotation.—This is the movement of a bone upon an axis, which is the axis of the pivot on which the bone turns. This form is seen best in the rotation between

the atlas and axis when the odontoid process of the axis serves as a pivot around which the atlas turns.

The Apposition of Joint Surfaces.—This is accomplished by (1) atmospheric pressure—as in the hip-joint; (2) synovial fluid; (3) ligaments to a small extent; (4) muscles to the greatest extent. A short muscle may act on more than one joint—the gluteus maximus extends the hip and also the knee through its insertion into the fascia lata.

NOTE.—The various articulations of the body have not been described, as they are beyond the scope of this book. However, a general understanding of their attachment, position, and the bones they hold together can be obtained from the plates.

QUESTIONS

1. Name the structures which enter into the formation of a joint.
2. What are the functions of ligaments?
3. Describe a synovial membrane.
4. Give the varieties of synovial membranes.
5. Do joints contain a fluid? What is its function? Name?
6. Where are the varieties of synovial membranes located usually?
7. Give the classification of joints included under the three main groups.
8. Give examples of an immovable joint or synarthrosis. Mixed joint or amphiarthrosis. Movable joint or diarthrosis. (See Table of Articulations.)
9. What movements are admitted in joints generally?
10. What do you understand by flexion? Extension? Abduction? Adduction? When occurring in the movements of a joint?
11. By what means are joint surfaces held in apposition?
12. What do you understand by the terms: Gliding movement? Angular movement? Circumduction? Rotation?

CHAPTER VII

MUSCLE TISSUE

Myology is the branch of anatomy which describes the muscles—muscle tissue.

Muscle tissue consists of cellular elements arranged in large masses to form muscles, which are attached to the bones of the body, and enter into the structure of numerous organs in such a manner that by their contraction they are able to perform the various movements of the body and functions of contained organs, whether of a voluntary or involuntary nature.

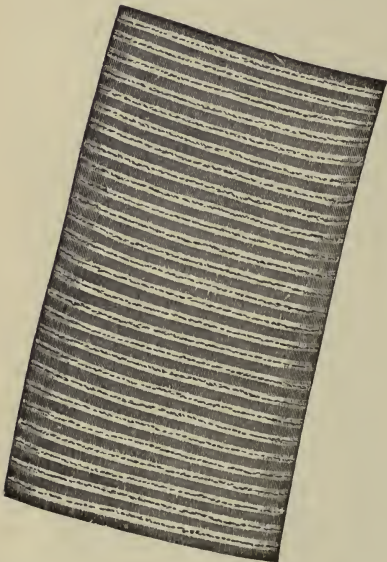
Classification. — The varieties of muscles are: **voluntary striated, involuntary non-striated,** and **involuntary striated.**

Voluntary Striated.—These muscles are characterized by being under the control of the will, also called skeletal muscles, owing to their attachment to bones which they move and assist to hold in position. Each muscle if examined microscopically will be seen to consist of a number of fibers, bound together by white fibrous tissue. Each fiber is a long, narrow cylinder. It varies in length from 1 to 5 inches, and exhibits cross and longitudinal striations. The composition of each fiber is a number of small fibers—called fibrillæ, surrounded by a membrane—the sarcolemma, and separated by a clear, transparent substance called sarcoplasm, and many peripherally located nuclei. The sarcoplasm represents the true muscular substance. The longitudinal striations or bands seen are formed by the alteration of the fibrillæ and the sarcoplasm, but are not quite as distinct as the crossed

band. The crossed striations are due to the change in the light and dark disks or bands.

The sarcolemma does not possess the inherent quality of contractility, but the sarcoplasm does.

Fig. 59



Part of a fiber of cross-striped muscular tissue, showing the alternating bands. (Gerrish.)

Fig. 60

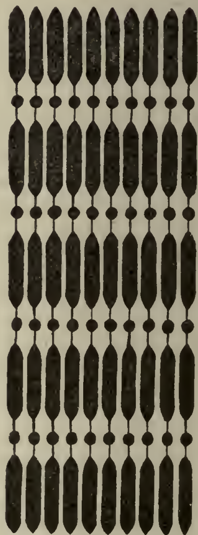


Diagram showing the minute structure of cross-striped muscular tissue. (Gerrish.)

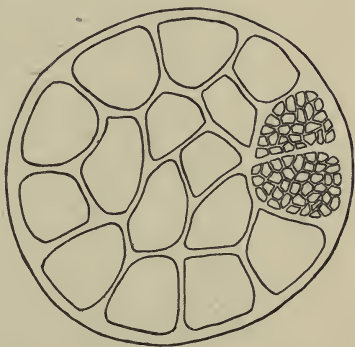
It has been shown that the fibrillæ form the fibers, the latter being grouped into primary bundles called fasciculi, and these primary bundles are collected into a series of bundles called secondary bundles, and groups of the latter form the completed muscle. Each muscle is surrounded by a sheath of white fibrous tissue called the **epimysium**, which gives off septa or layers from

its under surface to enclose the secondary bundles of fibers. The primary bundles receive from the sheath surrounding the secondary bundles a sheath called the **perimysium.** The latter sends fibers that pass between the individual fibers of the primary bundle, called the **endomysium.**

FIG. 61

Fragment of a fiber of cross-striped muscular tissue, showing fibrils separated at one end by teasing. (Gerrish.)

FIG. 62



Sheaths of muscular tissue in cross-section. The muscular tissue does not appear, but is represented by the spaces between the partitions. Outside of the entire muscle is *epimysium;* between the bundles is *perimysium;* between the fibers is *endomysium*—the last shown in two areas at the right. Diagrammatic. (F. H. G.)

The bloodvessels to muscle tissue pierce the epimysium and give off branches which follow the larger septa between the bundles until the perimysium is reached and smaller vessels form, which pierce the perimysium to form longitudinal capillaries; the latter anastomose freely with each other.

The lymphatics are not numerous and are sometimes wanting. The nerves follow the bloodvessels (see nerve system—nerve endings (page 339).

Voluntary striated muscles are found attached to

the skeleton and the external muscles of the eye-ball, in the tongue, the pharynx, upper part of the esophagus, anus, diaphragm, larynx, and external ear.

Involuntary Non-striated, Smooth or Visceral Muscle.—It is not under the control of the will. The individual fibers are short, narrow, and spindle-shaped. Each fiber is surrounded by a sheath, but it is not a sarcolemma. The fibers show longitudinal striation at the periphery due to the presence of fibrillæ, but no transverse striation. There is only one nucleus, which is narrow, elongated, and centrally located.

The fibers form bundles, but instead of being formed into masses like the voluntary striated variety, they are arranged into layers which extend circularly, obliquely, and longitudinally in the construction of the hollow organs of the body.

Bloodvessels are arranged as in the former variety.

The nerves are mostly derived from the sympathetic system.

Non-striated muscles are found in the walls of the alimentary tract, extending from the middle third of the esophagus to the anus, in the ducts of glands, trachea, and bronchial tubes, the eyé-ball, the internal genito-urinary apparatus, walls of bloodvessels (except the heart) and lymphatic system, and the capsules of some organs.

Involuntary Striated or Cardiac Muscle.—It is found in the muscle of the heart. The fibers are short cylinders, showing striations, but no sarcolemma. A delicate sheath surrounds the fibers. The nucleus is large, oval, and placed in the centre of a zone of undifferentiated protoplasm, filled with pigment granules. There are seen longitudinal and transverse striations in this variety, the latter being fainter. The fibers of this variety branch and join with the branches of other muscle cells.

The bloodvessels are derived from the coronary

arteries and small branches, are in intimate relation with the fibers, the smaller branches running parallel to the muscle bundles and sometimes lying within them. The nerves are derived from the sympathetic and cerebrospinal systems; sympathetic ganglion are also present.

The Physiological Properties of Muscle Tissue.—Consistency.—The **consistency** of muscle during life depends upon the activity of the part upon which the muscle is acting. Relaxed muscles are soft and fluctuating; when touched under tension or doing work the muscles are hard and resistant. The degree of tension of course depends upon the size of the muscle and the amount of work required.

Cohesion.—Cohesion of muscle depends upon the amount of connective tissue it contains; and it is this which enables it to resist the forces of traction and pressure.

Elasticity.—Muscle possesses great elasticity, or the power to stretch beyond its normal length through the action of external forces, and of resuming the normal length when those forces are removed. The degree of elasticity of muscle during life depends upon the proper amount of nourishment, exercise, healthy condition of blood, unimpaired nerve supply, and absence of any pathologic or diseased condition. Should any of these conditions interfere, the elasticity would be impaired.

Tonicity.—This is the tension or tonus of the muscle and is a property which is essential to counteract the stretching of a muscle and then to return and maintain it in a normal state, ready to be acted upon by the ensuing contractions.

Irritability and Contractility. — All muscles when irritated by a stimulus will respond by a change of shape, becoming shorter and thicker—called **muscular contraction,** and on withdrawing the stimulus the muscle will resume its normal shape and position.

The Muscle Stimuli.—In the living body all muscle tissue contracts in response to nerve impulses sent from the central nerve system to the muscles. Experimentally and artificially muscles are stimulated to contract by various stimuli, *e. g.*, **mechanic**—pinching, striking, or cutting a muscle; **chemic**, numerous chemical solutions; **thermic**, heated object, as hot needle or wire will cause a rapid contraction; **electric**, as batteries are used by physicians as therapeutic agents or upon animal tissue during experiments in the laboratory.

Attachments of Muscles.—Muscles are attached to bones, cartilages, ligaments, or skin by means of short, or long, rounded fibrous cords called **tendons**, or by short, flat, fibrous membranes called **aponeuroses.** All muscles, though they appear to be attached to bone or cartilage, in reality fuse with the periosteum or perichondrium at the point of attachment and do not touch the bone or cartilage. Muscles attached to the skin are flat and thin and their fibers fuse with the areolar tissue just beneath the skin, as the muscles of the face.

Muscles vary as to their form. Some are long, and flat or round; others short, and flat or round; still others triangular and quadrilateral in shape.

The origin of a muscle is called its **head**, and the portion which intervenes between the head and the tendon or aponeurosis is termed the **belly** or **body** (venter).

Muscles derive their names from the part of the body in which they are situated; the tibialis anticus—the anterior tibial region, ulnaris—ulnar region, radialis, radial region, etc.; from the direction their fibers take —rectus abdominis, obliquus hallucis, transversalis; according to their use or action—flexors, extensors, abductors, adductors, levators, compressors; from their shape—deltoid, trapezius, digastric; according to their number of divisions—biceps, triceps; from

their points of attachment—sternohyoid, sternomastoid.

In describing a muscle we speak of its **origin** and **insertion**, the former term meaning its more fixed point or central attachment of the head, while the latter means the movable point to which the force of the muscle is directed and upon which it acts when it contracts. However, the majority of muscles act from either their point of origin or insertion. The exceptions are the muscles of the face, which arise from the bone and are inserted into the skin.

It must be remembered that no single muscle can perform a movement alone: It requires several muscles, one set to fix the limb or part called fixation muscles, and another to act upon the part to be flexed, extended, abducted, etc.

Tendons.—Tendons when seen during life or in the recent state are white, glistening, fibrous cords, of different size and shape, some are long and short, thick, rounded, and flattened; consist mostly of white, fibrous tissue, very strong and non-elastic. Their blood-supply is very scant. The smaller tendons not showing a trace of blood. The nerve endings have special terminations called neurotendinous spindles or crgans of Golgi. The tendons are attached to the belly of the muscle by one extremity; to the periosteum of bone or perichondrium of cartilage by the other, and are usually the part which is called the insertion. However, some muscles have a tendon at either extremity, as the biceps and triceps, and others present two muscular bellies with a tendon between, as the digastric muscle.

Aponeuroses.—These are similar in structure to tendons; they are flat, white, fibrous membranes attached by one extremity to the muscle and by the other to the bone, cartilage, ligament, or skin—as the gluteus maximus muscle. They usually are associated with thin or thick flat muscles just beneath the

skin and fascia. They are not supplied by nerves, and possess a meager blood-supply.

Fasciæ.—When the skin is removed the structure beneath will appear as a silvery-white layer through which are seen the muscles, and contained superficial nerves and bloodvessels. This is known as the fascia which covers the muscles as a sheath, also forms support and coverings for the various organs. It consists of layers of fibro-areolar connective tissue. In certain parts of the body the fascia is found in two layers—**superficial** and **deep** and often three, as the thigh. Certain muscles are lodged in the layers of fasciæ, as the platysma muscle in the neck, and the orbicularis palpebrarum muscle around the eyelids. The deep fascia usually forms sheaths for the individual muscles of an extremity, as in the thigh, where the membrane encloses it as a stocking; this arrangement increases the tension and pressure, thus assisting the muscles in their action. In addition the deep fascia gives off septa or walls which separate the muscles of the limbs, and are deeply attached to the periosteum of the bone; these are called **intermuscular septa.** Near the wrist-joint the deep fascia becomes thickened and reinforced by transverse fibers to assist in holding in firm position (front and back) the tendons passing to the hand and fingers; also near the ankle-joint is a similar arrangement for the tendons passing to the foot and toes. They are called **annular ligaments.**

Description.[1]—The description of a muscle includes: the **location, origin, insertion, relations, action, nerve,** and **blood-supply.**

THE MUSCLES OF THE HEAD AND NECK

The Cranial Region or Scalp.—The scalp consists, from without inward, of the skin, a layer of adipose

[1] The most important muscles only will be described.

tissue (fat), epicranial aponeurosis, subaponeurotic tissue, periosteum, and bone. The skin is very thick and contains the hair follicles, closely related. The superficial fascia beneath the skin contains fat, superficial bloodvessels, and nerves of the scalp; it is continuous behind with the fascia of the neck; on the sides it is continued over the temporal fascia. The layers of the scalp are all blended firmly together.

The Occipitofrontalis Muscle.—This is a broad, thin layer, consisting of two muscular portions with an intervening aponeurosis. The occipital portion or **occipitalis muscles** is attached behind to the outer two-thirds of the upper curved line on each side of the occipital and mastoid portion of the temporal bones. The frontal portion, or **frontalis muscle, arises** from the aponeurosis between the frontal eminence of the frontal bone and the coronal suture, and has no bony attachments.

Actions.—The frontalis elevates the eyebrows, draws the scalp forward, and wrinkles the forehead transversely; occipitalis draws the scalp backward, or alternates with the frontalis in moving the scalp back and forth—some individuals can move the scalp voluntarily.

The Nerve Supply.—Frontalis by temporal branches of the facial nerve; occipitalis by the posterior auricular branch of the facial.

The Muscles to the External Ear (Auricular Region)

Attrahens aurem.
Attollens aurem.
Retrahens aurem.

They are three small muscles placed just beneath the skin; sometimes they are scarcely visible in man,

consisting of a few scant fibers. In mammalia they are particularly well-developed—as the rabbit, etc.

Actions.—Is not marked in man. Attrahens draws the ear forward and upward; attollens raises it slightly; retrahens draws it backward.

Muscles of the Eyelids and Eyebrows (Palpebral Region)

Orbicularis palpebrarum
Corrugator supercilii
Tensor tarsi

Orbicularis Palpebrarum.—This is a flat muscle, consisting of circular fibers which surround the circumference of the orbit and eyelids. Origin from the upper and lower margins of the internal tarsal ligaments and passes out in a slight curve across the upper lid to the external tarsal ligament. The orbital portion is the larger and stronger, is attached to the nasal process of superior maxilla, inner part of orbital arch, and externally overlies the cheek and temple forming a series of concentric loops. The upper fibers of this portion of the muscle blend with the fibers of the occipitofrontalis and corrugator supercilii muscles.

The Tarsal Ligaments.—**Internal Tarsal Ligament** or **tendo-oculi** is $\frac{1}{6}$ inch in length and about the same in breadth. **Attached** to the nasal process of the superior maxilla in front of the lacrymal groove, then it passes to the inner commissure of the eyelids, splitting and ending in the inner extremity of the corresponding tarsal plate of the eyelids; crossing the lacrymal sac the tendon gives off a strong aponeurotic layer from its posterior surface, which spreads over the sac, and is attached to the ridge on the lacrymal bone—this latter is the reflected aponeurosis of the tendo oculi. The **external tarsal ligament** is weaker than the former and **arises** from the frontal process

of the malar bone to be **inserted** into each tarsal plate at the external commissure of the eyelids.

Actions.—Orbicularis palpebrarum is the muscle which closes the eye suddenly, as in winking, or as a protection in shutting the eye against the entrance of a foreign body. The palpebral portion closes the lids, as in sleep. The **tendo-oculi** serves to suck the tears into the lacrymal sac, by its attachment to the sac. (See Lacrymal Apparatus, page 398).

Nerve Supply—facial nerve.

Corrugator Supercilii.—They are two small muscles found at the inner extremity of the eyebrow, beneath the occipitofrontalis and orbicularis palpebrarum, with which they fuse.

Action is to draw the eyebrow downward and inward and to form the vertical wrinkles of the forehead; it is called the "frowning" muscle, and is the means of expressing anxiety, suffering, and thought.

Nerve Supply—facial nerve.

The Muscles of the Orbit (Orbital Region)

Levator palpebræ superioris	Rectus internus
Rectus superior	Rectus externus
Rectus inferior	Obliquus oculi superior
Obliquus oculi inferior	

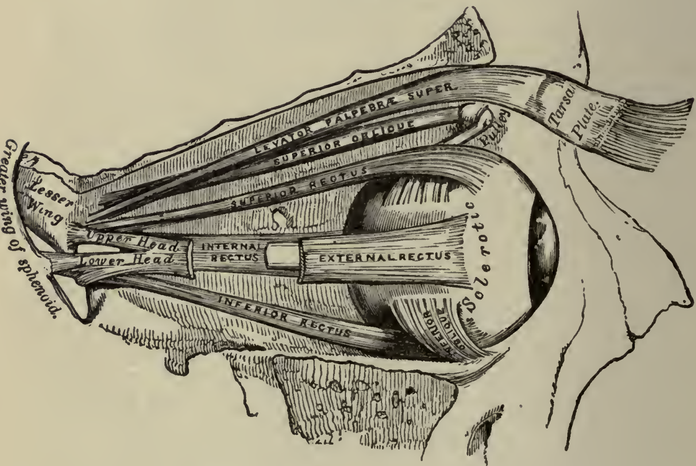
Levator Palpebræ Superioris.—This, the elevator of the upper lid, is a thin, flat, and slightly triangular-shaped muscle found within the orbital cavity (and like the other muscles of this group cannot be seen until the skull-cap has been removed and the roof of the orbit opened) above the eye-ball.

Actions.—Raises the upper eyelid and is the opposite in action to the palpebral portion of the orbicularis palpebrarum.

Nerve Supply.—Motor oculi or third cranial nerve.

The Four Recti Muscles.—They arise from a common fibrous membrane attached at the apex of the orbital cavity, above, below, and internal to the margins of the optic foramen and fuse with the optic nerve. They all pass obliquely forward and are **inserted** into the superior, inferior, internal, and external portions of the eye-ball (in the position implied by their names) by a tendinous expansion into the sclera (outer coat of eye-ball) about $\frac{1}{4}$ of an inch from the cornea.

Fig. 63



Muscles of the right orbit. (Gray.)

Actions.—The four recti are so attached that they are able to turn the eye-ball in the direction desired, expressed by their names—thus upward, downward, inward, or outward. The obliquus oculi superior and inferior assist the superior and inferior recti to turn the eye-ball downward, inward, or outward, and upward, outward, or inward. The internal and external recti also assist in these complicated actions of the eyes.

Nerve Supply.—All supplied by the motor oculi or third cranial nerve, except the external rectus, and it is innervated by the abducent or sixth cranial nerve; the superior oblique is supplied by the trochlear or fourth cranial nerve.

The Muscles of the Nose (Nasal Region)

Pyramidalis nasi.
Levator labii superioris alæque nasi.
Dilator naris posterior.
Dilator naris anterior.
Compressor nasi.
Compressor narium minor.
Depressor alæ nasi.

The above muscles are just beneath the skin and fascia and most of them are inserted into the skin; they arise from the bones, fascia, and cartilages.

The Muscles of the Cheeks and Lips (Maxillary Region)

Levator labii superioris.
Levator anguli oris.
Zygomaticus major.
Zygomaticus minor.

The Levator Labii Superioris.—**Origin,** lower margin of orbit, some fibers from maxilla and malar bones, insertion into muscular portion of upper lip. **Action**—elevates and assists in protruding the upper lip. **Nerve,** facial.

The Levator Anguli Oris.—**Origin,** canine fossa of maxilla; **inserted** into skin and fascia near angle of mouth, blending with the fibers of the zygomaticus major, depressor anguli oris, and orbicularis oris. **Action**—elevates angle of mouth. **Nerve,** facial.

Zygomaticus Major.—**Origin,** malar bone; inserted into skin and fascia outer portion of upper lip and angle of mouth, blending with the fibers of the levator anguli oris, orbicularis oris, and the depressor anguli oris. **Action**—draws the angle of the mouth upward and backward, as in laughing. **Nerve,** facial.

Zygomaticus Minor.—**Origin**, malar bone; **inserted** into skin and fascia of upper lip internal to angle of mouth and the insertion of the zygomaticus major; fuses with fibers of orbicularis oris. **Action**—draws the upper lip backward, upward, and outward, thus gives to the face an expression of sadness. **Nerve**, facial.

The Muscles of the Chin and Lower Lip (Mandibular Region)

Levator menti.
Depressor anguli oris.
Depressor labii inferioris.

Levator Menti.—**Origin**, mandible external to symphysis; **inserted** into skin of chin. **Action**—raises lower lip, wrinkles chin, gives to the face the expression of doubt, disdain, and pouting. **Nerve**, facial.

Depressor Anguli Oris.—**Origin**, from mandible, **inserted** into angle of mouth. It is blended with the platysma, orbicularis oris, risorius, and levator anguli oris. **Action**—depresses angle of mouth. Acting with the levator anguli oris the two will depress angles of the mouth directly inward, as in smirking. **Nerve**, facial.

Depressor Labii Inferioris.—**Origin** from mandible; **insertion**, skin of lower lip, blends with fibers of orbicularis oris and muscle of opposite side. **Action** depresses lower lip. **Nerve**, facial.

The Muscles of the Buccal Region

Orbicularis oris.
Buccinator.
Risorius.

Orbicularis Oris.—This is the muscle of the mouth and lips. It consists of oblique and transverse fibers

which are not distinct, but fuse with the muscles inserted into the skin and mucous membrane surrounding the mouth. The buccinator muscle divides at the angle, and the fibers pass into the upper and lower part of the orbicularis oris; also at the angle entering from above are the fibers of the levator anguli oris, and from below the fibers of the depressor anguli oris. In addition to the former muscles crossing at the angle, are the fibers of the risorius which divide and blend with the upper and lower lips respectively. The other muscles inserted into the lips are: above, levator labii superioris (elevator of upper lip); levator labii superioris alæque nasi (elevator of the upper lip and wing of the nose); the zygomaticus major and minor; and depressor labii inferioris (depressor of the lower lip). **Actions** are numerous and various, and only the ordinary or chief actions will be mentioned, as the muscles inserted into the orbicularis oris all aid it in the complex movements of this important muscle of expression. When the fibers contract they close the lips; the crossed fibers consisting of the superficial set brings the lips together and also protrudes them as in whistling, pouting, etc., the deep fibers assisted by the oblique fibers forcibly close the lips and hold them against the teeth—as when one refuses to take food or medicine by mouth.

Nerve—facial.

Buccinator.—This is the chief muscle of the cheek, and encloses the space between the two jaw bones. It is thus quadrilateral in shape. **Arises** from the alveolar processes of the maxillæ and mandible, behind from a thickened fibrous band, called the pterygomandibular ligament. The fibers come together at the angle of the mouth and pass to the upper and lower lips. **Action**—it is essentially a muscle of mastication. The muscle contracts the cheeks and compresses them so that the food during mastication is kept within the bounds of the teeth and comes in contact with their chewing

or grinding action. When the cheeks are distended with air, the muscle contracts and expels it through the lips as in playing the cornet, flute, etc.

Nerve—facial.

Risorius.—A small thin muscle **arises** from the fascia over the masseter muscle, **inserted** into muscular and subcutaneous tissue at the angle of the mouth.

Action.—Draws back the angle of the mouth as seen in lockjaw, giving the peculiar expression to the face known as the "**sardonic grin** or laugh;" also (both sides) assists in retracting angles of mouth as in smiling, associated with the other muscles at the angle.

Nerve—facial.

Muscles of Mastication

Temporomandibular region.	Pterygomandibular region.
Masseter.	External Pterygoid.
Temporal.	Internal Pterygoid.

The muscles of mastication aid in preparing the food so that it can be easily swallowed. They bring the jaws together, so that the teeth approximate and chew, or by a lateral motion, grind the food.

The Muscles of the Tongue (Lingual Region)

The muscles of the tongue are divided into extrinsic, those situated outside of the organ, yet are inserted into it; and **intrinsic**, those contained within the organ, forming its substance.

The Extrinsic Muscles.—These are: **geniohyoglossus, hyoglossus, styloglossus, palatoglossus,** and **chondroglossus.**

The Intrinsic Muscles.—These are a series of interlacing fibers making up the substance of the tongue and are named according to their position and direction, called **lingualis,** presenting—superior, inferior,

transverse, and vertical fibers, with a medium fibrous septum. They all receive fibers from the extrinsic muscles at their points of insertion into the tongue.

The Muscles of the Soft Palate (Palatal Region)

The soft palate is continued back from the hard palate, and is seen on opening the mouth as an arch with a central projection called the uvula, directly over the back of the tongue. Beneath the mucous membrane covering these parts are the muscles of the soft palate, as follows:

Levator palati.	Palatoglossus.
Tensor palati.	Palatopharyngeus.
Azygos uvulæ.	Salpingopharyngeus.

The Muscles of the Pharynx (Pharyngeal Region)

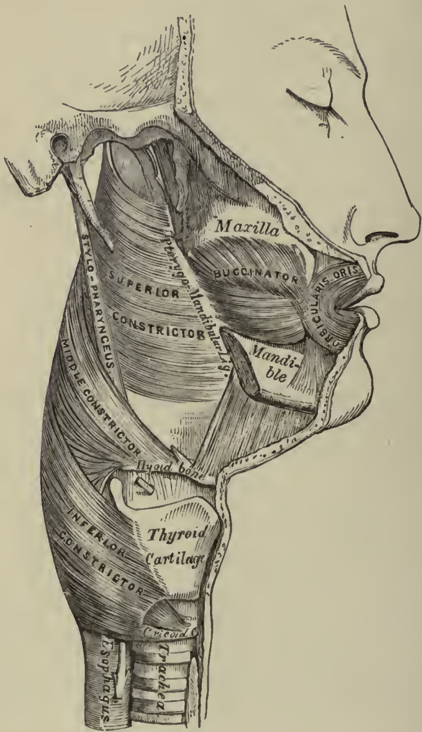
Superior constrictor.	Inferior constrictor.
Middle constrictor.	Stylopharyngeus.
Salpingopharyngeus. Palatopharyngeus.	} See muscles of soft palate.

These muscles are divided into two layers—an outer flat and thin one—called the constrictors, with a transverse set of fibers; an inner—called the elevators, two in number, with a longitudinal arrangement of the fibers.

Actions of pharyngeal muscles. Their chief function is to assist in swallowing the food after it has been masticated and forced into the pharynx by the tongue and muscles of the soft palate. At the beginning of deglutition the sides of the pharynx are raised upward and outward by the two stylopharyngei muscles, at the same time the larynx and tongue are carried forward. When the bolus of food is being received into the pharynx, the elevator muscles relax and the

constrictor muscles contract upon the mass and force it into the esophagus.

Fig. 64



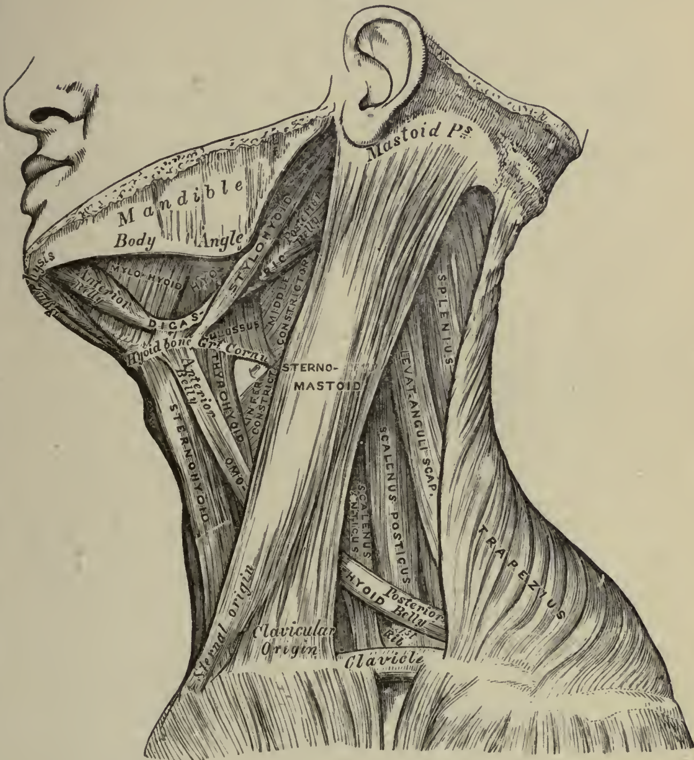
Muscles of the pharynx. External view. (Gray.)

The Muscles and Fasciæ of the Neck

The neck muscles are divided into a superficial and a deep set. They are arranged vertically and only the anterior or superficial set will be described, as the others are not important so far as the nurse's knowledge is concerned.

The Anterior Neck Muscles.—The **platysma** is a thin, pale muscle, extending over the front and sides of the neck, the lower region of the face, and as low as the

Fig. 65



Muscles of the neck and boundaries of the triangles. (Gray.)

upper aspect of the chest, just below the clavicles. It is just beneath the skin, invested by the superficial fascia, and above the deep cervical fascia of the neck. There are two such muscles.

The Sternomastoid.—Origin, from anterior surface of the sternum, inner third of upper surface of clavicle; two portions meet and pass obliquely upward and back across the lateral aspect of the neck to be **inserted** into the anterior border and outer surface of the mastoid portion of the temporal bone.

Actions.—The two muscles acting together bend the head upon the neck. When only one muscle contracts the head is drawn toward the shoulder of the same side, at the same time the head is rotated, so that the face is carried to the opposite side. When the head is held firm by the other muscles the sternomastoid acts as a muscle of respiration in forced breathing. Nerve—spinal accessory and deep branches of cervical plexus.

Depressors of the Hyoid Bone

Sternohyoid.	Thyrohyoid.
Sternothyroid.	Omohyoid.

The Elevators of the Hyoid Bone

These muscles are situated at the inferior and lateral aspect of the floor of the mouth, below the mandible. They are covered by the deep cervical fascia of the neck.

Digastric.	Mylohyoid.
Stylohyoid.	Geniohyoid.

Deep Neck Muscles

There are numerous neck muscles deeply located in the neck; they assist to maintain the head erect and also aid in flexing, extending, and rotating the head on the spinal column. A description of these muscles will not be given, as they cannot be properly understood

unless seen, either in a diagram, or the human body. Other muscles arising from the cervical vertebræ pass to the ribs and aid in forced inspiration and expiration; still others posteriorly pass to the scapulæ and thoracic vertebræ and assist in shrugging the shoulders, flexing and extending spinal column, rotating the vertebræ, etc.

THE MUSCLES AND FASCIÆ OF THE TRUNK

In speaking of the trunk we include that part of the human body consisting of the back, thorax, abdomen, and perineal region.

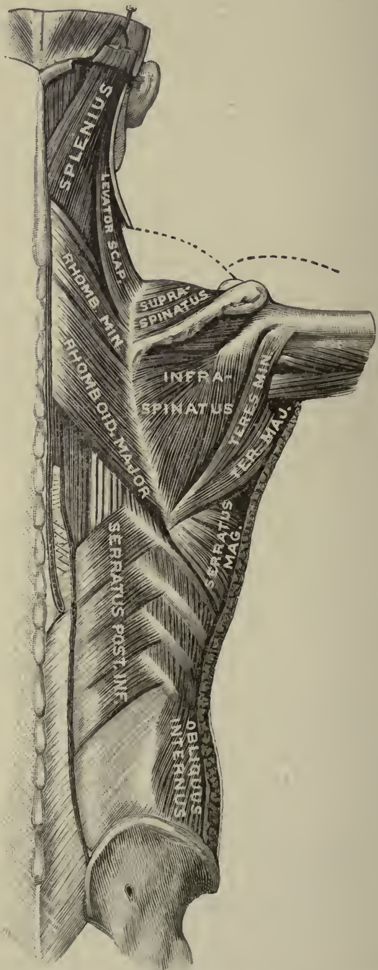
The Muscles of the Neck and Back

The muscles of these regions are in layers, their actions and relations are too complex to include here except the ones described below. It is sufficient to state that they consist of five layers, in which are thirty-two or more pairs of muscles. These muscles are covered by a superficial fascia which is continuous with the fascia over the rest of the body; and a deep fascia, which is thick and fibrous, and curves over and forms sheaths for the muscles, being attached to the following bony prominences: occipital bone, crest of ilium, spines of vertebræ, and the spines of the scapulæ. In the neck it forms the posterior portion of the deep cervical fascia, in the thorax blends with the axillary fascia and deep fascia of the thorax; it is continuous with the abdominal fascia, also forms the back layer of the lumbar fascia, and covers the erector spinæ mass of muscles.

The Trapezius.—This is the muscle situated at the back of the neck and shoulders. There are two. **Origin,** inner third of the superior curved line of the occipital bone, ligamentum nuchae, spinous processes of the seventh cervical and all the thoracic vertebræ and

supraspinous ligaments; **insertion,** fibers converge to shoulder girdle; superior ones to outer third or half

Fig. 66



Muscles in the second layer of the back and on the dorsum of the shoulder. (Testut.)

of the posterior border of the clavicle (collar bone); middle fibers horizontally to inner margin of acromion and superior lip of spine of scapula; inferior fibers terminate in a triangular aponeurosis, which glides over a smooth surface at the inner extremity of the spine to be inserted into a tubercle at the outer portion of this surface.

Latissimus Dorsi.—This is one of the largest and longest muscles in the body. Broad and flat at its origin, narrow at its insertion, it covers the lumbar region of the back and the lower half of the thoracic region. **Origin**, spinous processes of the lower six or seven thoracic vertebræ, posterior layer of lumbar aponeurosis which attaches it to the lumbar and sacral spines, and supraspinous ligament, from the outer lip of the iliac crest, also arises by three or four fleshy slips from three or four lower ribs. Its upper fibers pass horizontally outward, the middle obliquely upward, and the lower fibers vertically upward, they become narrowed into a tendon, $1\frac{1}{2}$ inches wide, which passes back of the arm-pit (axilla) in front of the teres major muscle, to be **inserted** into the **bicipital groove** on the anterior and upper aspect of the humerus (arm bone).

Actions.—Depresses arm; draws it toward body (adducts); turns it inward; acts in striking a blow or chopping wood, etc.; when arms are firmly held in position, it assists the chest and abdominal muscles to suspend and draw forward or upward the whole trunk, as in climbing, etc. **Nerve**—subscapular from brachial plexus.

The Muscles of the Thorax

External intercostals.	Triangularis sterni.
Internal intercostals.	Levatores costarum.
Infracostales (subcostales).	Diaphragm.

The Intercostal Muscles.—These are thin, flattened muscles extending between the margins of two adjacent ribs, filling the intervening spaces—called **intercostal.** These muscles are covered by the **intercostal fascia,** internally and externally, and a layer lies between the two muscles.

The Subcostals.—The subcostals (infracostals) or muscles below the lower ribs consist of muscular and aponeurotic fibers, which are attached to the inner surface of one rib (usually lower ribs), and **inserted** into the inner surfaces of the first, second, or third rib below. They are placed on the parts of the ribs where the internal intercostal muscles end posteriorly.

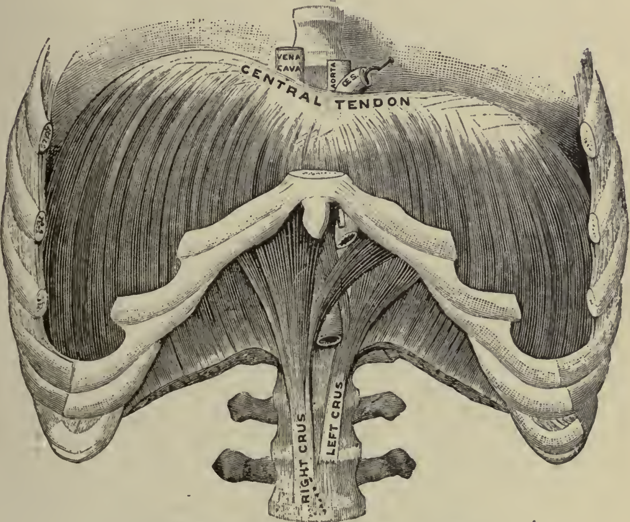
The Triangularis Sterni.—This is a thin, irregular-shaped muscle found on the posterior surface of the sternum (breast bone), and it passes to the costal cartilages of the ribs from the second to sixth inclusive. It is a single muscle.

The Levatores Costarum (Elevators of the Ribs).—These are twelve in number found on each side of the vertebral column external to the thoracic cavity. **Origin,** by small tendinous and fleshy bundles from the extremities of the transverse processes of the seventh cervical and the eleven upper thoracic vertebræ; pass obliquely downward and outward to be **inserted** into the upper border, between the angle and tubercle of the rib, immediately below its vertebra of origin. Each of the lower elevator muscles divides into two slips, one of which is inserted as described above the other slip passes to the second rib below its origin; thus each of the lower ribs receives fibers from two vertebræ.

Diaphragm.—This is a musculofibrous wall which divides the thoracic and abdominal cavities. It is dome-shaped; the convex, upper surface forms the floor of the thoracic cavity, and the concave lower surface the roof of the abdominal cavity. The attachments of the diaphragm are as follows: In front the

lower six cartilages—internal surface, back of ensiform; behind—from the lumbar vertebræ by two slips or crura; and from aponeurotic arches—the arcuate ligaments. The **crura** are found on the bodies of the lumbar vertebræ, on each side of the aorta. The internal arcuate ligament passes over the psoas muscle from the outer side of the body of the first lumbar vertebra to the lip of the transverse process. The

Fig. 67



Diaphragm, viewed from in front. (Testut.)

external arcuate ligament passes over the quadratus lumborum from the second transverse process to the tip of the last rib. The fibers of the diaphragm arise from these ligaments. The muscular fibers on reaching the centre became fibrous, and form the **central tendon** of the diaphragm. The fibers are interwoven in every direction. The pericardium (the serous membrane covering the heart) is attached to the upper surface of this central tendon.

There are three important openings in the diaphragm, and several smaller ones. The esophageal opening transmits the esophagus and vagi nerves, the esophagus continues as the stomach below the diaphragm; the aortic opening transmits the abdominal aorta, vena azygos major, and thoracic duct; it is the most posterior one; the opening for the inferior vena cava is the most anterior and transmits the large vein which carries the venous blood to the right side of the heart. The splanchnic nerves and the azygos minor veins pierce the diaphragm near the crura. The upper surface of the diaphragm is covered by pericardium in the centre, pleuræ on the lateral surfaces, and the under surface is covered by peritoneum.

Actions. — It is the chief muscle of respiration; thus when a deep breath is taken the diaphragm can be felt to extend downward making pressure on the abdominal organs, and at the same time increases the vertical diameter of the thoracic cavity, allowing the lungs to fill more readily with air. The diaphragm also contracts in all expulsive acts, as sneezing, laughing, crying, coughing, and in the act of defecation, urination, and expulsion of the fetus during delivery, it assists the abdominal muscle to raise the intra-abdominal pressure. The action of the diaphragm can be seen in patients under ether, when the upper portion of the abdomen will demonstrate the gradual and steady ascent and descent of the diaphragm under forced or abdominal breathing.

The Fasciæ and Muscles of the Abdomen

The fascia of the abdomen is divided into a superficial and deep portion. The **superficial** fascia is continuous above with the fascia of the thorax and back, below with that of the thigh. Its lower fourth on the abdomen divides into a superficial layer —

called Camper's fascia, and a deep layer — termed Scarpa's.

The deep layer is attached to Poupart's ligament, and is continued around the male and female genitalia; the superficial layer also passes to the male and female genitalia. The **deep** fascia of the abdomen is so adherent to the underlying structures that it is difficult to see.

The Muscles of the Abdomen.—They are as follows:

External oblique.	Transversalis.
Internal oblique.	Rectus.
Pyramidalis.	

The external and internal oblique and the transversalis are thin, flat, broad muscles which possess aponeuroses and they all form with the rectus the anterior and lateral abdominal walls, being lined—the transversalis—by the peritoneum. They are arranged one on either side. The aponeuroses of the oblique and transversalis pass toward the outer edge of the rectus and ensheath the two halves. In a general way the oblique and transversalis muscles are attached to the lower ribs, crest of the ilium, and Poupart's ligament.

The Fasciæ and Muscles of the Thoracic Region, Fascia, of Pectoral Region (Chest).—*Superficial* contains the mammary gland, sending septa into it and supporting it. The *deep fascia* is thin, covering the surface of the pectoralis major muscle; it is attached to the middle of the front of the sternum, above to the clavicle, and below is continuous with the fascia over the shoulder, axilla, and thorax. It encloses the space between the pectoralis major and latissimus dorsi muscles; it is called in this region the **axillary fascia.**

THE MUSCLES OF THE ANTERIOR THORACIC REGION. These are as follows:

Pectoralis major.	Subclavius.
Pectoralis minor.	

Pectoralis Major.—This **arises** from the inner half of the anterior surface of the clavicle, the sternum, from the upper six rib cartilages and from the anterior sheath of the rectus and external oblique aponeurosis. The fibers converge to be **inserted** by two tendons, united along the lower margin, into the external bicipital ridge of the humerus.

Subclavius.—This **arises** from the groove on the under surface of the clavicle and recess between the conoid and trapezoid ligaments: **inserted** into the junction of the first rib with its cartilage between the fibers of the costoclavicular ligament.

Pectoralis Minor.—This **arises** from three ribs near their cartilages, usually the third, fourth, and fifth, often the second, third, and fourth or fifth, and from the intercostal aponeurosis; **insertion**, inner border and upper surface of the coracoid process of the scapula; a bursa is under its insertion.

The **linea alba** is a narrow depression seen along the middle line of the abdomen, extending from the tip of the breast bone—ensiform—to the symphysis pubes. It is formed by the union of the aponeuroses of the oblique and transversalis muscles, which surround the recti muscles and adhere to the fascia and skin. A little below the midpoint of the linea alba is a scar—the result of the healed umbilical cord, called the umbilicus (navel).

The **linea semilunaris** is a depression seen on the outer side of each rectus abdominis muscle, and corresponds to the line of fusion of the aponeuroses of the oblique and transversalis muscles, as they blend to pass in front and behind the recti muscles to form the sheath of the latter muscles. It extends from opposite the ninth costal cartilage to the spine of the pubic bone.

Lineæ transversæ are depressions seen along the recti muscles, and correspond to the attachment of the aponeuroses of the abdominal muscles to the rectus. They are usually three—one below the ensiform car-

tilage, one between the ensiform and the umbilicus, and one opposite or below the umbilicus.

Actions of the Abdominal Muscles.—When the thorax and pelvis are fixed these muscles acting together constrict the abdominal cavity, and raising the intra-abdominal pressure—also assisted by the diaphragm—aid in expelling the fetus from the uterus, feces from the rectum, urine from the bladder.

The Posterior Muscles of Abdomen (Iliac Region)

The **iliac fascia** covers the iliopsoas muscle, within the back part of the abdominal cavity stretched from the iliac crest to the iliac portion of the iliopectineal line. Below it passes beneath the femoral vessels, forming the hinder part of the femoral sheath; outside the vessels it unites with the transversalis fascia at Poupart's ligament.

Quadratus Lumborum.—A quadrilateral muscle placed between the last rib and the pelvis. **Origin,** iliolumbar ligament, external lip of the crest of the ilium for two inches, from two, three, or four lumbar transverse processes by fleshy slips passing up anteriorly; **insertion,** inner half of last rib and upper four lumbar transverse processes.

Nerves.—Last dorsal and upper lumbar.

Actions.—Lateral flexion of both may extend the spine. Draws down the last rib, giving fixed point for the diaphragm, and aids inspiration. Fixed above, draws pelvis to one side, or both draw it forward.

ILIOPSOAS.—It has a broad outer head, iliacus, and a narrow inner head, psoas magnus.

Iliacus.—**Origin,** upper half of the iliac fossa down as far as the anterior inferior spine, posteriorly from ala of the sacroiliac and iliolumbar ligaments. **Inserted** mostly into tendon of the psoas; outermost fibers pass to the femur in front of and below the small trochanter.

Psoas Magnus (or Major).—**Origin,** by five fleshy slips from anterior surfaces and lower borders of the lumbar transverse process, and by a series of processes, each from a disk and contiguous margins of two bodies; the highest is attached to the last thoracic and first lumbar, and lowest to the fourth and fifth lumbar and intervertebral substance between them; fibers also come from the sacroiliac joint and sacrum. These attachments are connected with arches passing over the middle of the vertebræ. The fibers all unite to a thick, long muscle running along the brim of the pelvis, passing under Poupart's ligament, and **inserted** by a tendon into the small trochanter; separated by a bursa.

The common tendon is also separated from the capsule of the hip by a bursa.

Psoas Parvus (or Minor).—Placed on the surface of the psoas magnus; **rises** from the bodies of the last thoracic and first lumbar vertebræ and disk between; **ends** in a flat tendon merged into the iliac fascia and inserted into the iliopectineal line and eminence. When present its origin is variable; was absent on both sides in 40 per cent. of cases.

The Muscles and Fasciæ of the Perineum

These are the structures which enclose the space between the rami of the pubes and ischii on both sides and the pubic arch and subpubic ligament in front, while they are bounded behind by a line extending transversely between the anterior edge of the tuberosities of the ischii on both sides. The space in front of this line is termed the **perineum,** and behind the line, the space in front of the coccyx, is called the **ischiorectal region**; this space is bounded on the sides by the gluteus maximus muscles.

The perineum can be demonstrated only by having the subject on its back with the limbs flexed on the

abdomen. The structures to be seen are the anus (outlet of rectum), the scrotum in the male, and the vagina in the female.

The perineum is covered by skin, **superficial fascia** divisible into a superficial layer, and a deep layer—called **Colles'.**

The **deep perineal** or **subpubic fascia** or **triangular ligament of the urethra** is stretched across the subpubic arch and consists of two layers; the *inferior* layer extends back to the central point of the perineum, attached to the ischiopubic rami, connected at its base with the other layer, and continuous with the recurved margin of the superficial perineal fascia.

The *superior* (deep) layer consists of right and left lateral halves, separated in the middle line by the urethra close to the prostate, and continuous on each side with the fascia covering the obturator internus muscle. The levator ani muscle is between this layer and the rectovesical fascia.

MUSCLES AND FASCIÆ OF THE UPPER EXTREMITY

Muscles and Fasciæ of the Shoulder

The Acromial Region.—The deep **fascia** is strong and tendinous over the back of the deltoid and infraspinatus; the infraspinatus fascia covers the teres minor and splits at the posterior border of the deltoid, a deep layer passing to the shoulder-joint under that muscle, a superficial layer to the spine of the scapula over the muscle.

Deltoid.—**Origin** in three portions: an anterior from the front of the outer third of the clavicle, a middle from the point and outer edge of the acromion, a posterior from the lower border of the scapular spine and triangular surface at its inner end, and from the infra-

spinatus fascia. These converge into the tendon of **insertion** into the deltoid tubercle of the humerus.

The Posterior Scapular Region.—The muscles of this region are as follows:

Supraspinatus.	Teres major.
Infraspinatus.	Teres minor.

Supraspinatus.—This **arises** from inner part of the supraspinous fossa to region of the notch, from supraspinous fascia and transverse ligament; adherent to capsule and infraspinatus tendon; **inserted** into the upper of the three facets on the great tuberosity of the humerus.

Infraspinatus.—It **arises** from the inner two-thirds of the infraspinous fossa, and under surface of the spine of the scapula, the fibers converge to a tendon concealed within the muscle and **inserted** into the middle facet of the great tuberosity. It may be inseparably connected with the teres minor.

Teres Minor.—**Origin**, from narrow grooved surface on the back of the scapula close to the axillary border, from septa between it, the teres major, and infraspinatus; **inserted** into the lowest facet on the great tuberosity and into the shaft for a short distance below.

Teres Major.—Is a thick somewhat flattened muscle. **Origin**, from the oval surface on the back part of the inferior angle of the scapula, and the fibrous septa common to it, and the teres minor and infraspinatus; **inserted**, by a flat tendon into the inner ridge of the bicipital groove of the humerus.

The Anterior Scapular Region.—*Subscapularis.*—**Origin**, by muscular and tendinous fibers from the venter of the scapula and groove along the axillary border, **insertion**, small tuberosity of the humerus and into the shaft for a short distance. As in the deltoid, this muscle contains two sets of septa—one

from the origin, and one from the insertion for attachment of the oblique muscular fibers. Some fibers from the axillary border of the muscle are usually inserted into the capsule, known as the *subscapularis minor.*

The Muscles and Fasciæ of the Arm

The **aponeurosis of the arm** (deep fascia) is thin over the biceps, strong over the triceps, and is attached to the humerus, *intermuscular septa.*

The Muscles of the Anterior Humeral Region.—The muscles of this region are:

Biceps. Coracobrachialis.
Brachialis anticus.

Biceps.—Its *short* or *inner head* **arises** with the coracobrachialis from the tip of the coracoid process; the *long head,* **from** the upper end of the glenoid cavity; within the capsule by a tendon continuous on each side with the glenoid ligament; these two heads form a belly in the middle and lower part of the arm. The tendon of **insertion** is slightly twisted and attached to the back part of the tuberosity of the radius, separated from the forepart by a bursa. From the inner side of the tendon a part branches off as an aponeurotic band or *semilunar* fascia, and blends with the deep fascia of the forearm stretched across the brachial vessels and median nerve.

Coracobrachialis.—**Origin,** tip of the coracoid between the pectoralis minor and short head of the biceps; **insertion,** inner border and inner surface of the humerus near its middle, between the triceps and the brachialis anticus.

Brachialis anticus.—Arises from the lower half of the front of the humerus, nearly the whole of the internal intermuscular septum, and upper part of the external. It is adherent to the capsule of the elbow-

joint, and often sends a slip into it, and is **inserted** into the inner part of the rough surface at the junction of the coronoid process with the shaft of the ulna and to a part of the tubercle of the ulna.

The Muscles of the Posterior Humeral Region.—The muscles of this region are:

Triceps. Subanconeus.

Triceps occupies the entire posterior aspect of the humerus. Three heads are inserted into a common tendon occupying the posterior surface of the muscle from the middle of the arm to the elbow. The *middle* or *long head* **arises** from the inferior glenoid tubercle of the scapula and adjacent portion of the axillary border; this forms the middle and superficial part of the muscle and ends on the inner margin of the tendon. The *external head* **arises** above the spiral groove and from an aponeurotic arch of the external intermuscular septum as it crosses it, extending to the teres minor insertion above, and *inserted* into the upper end and outer border of the tendon. The *internal* or *deep head* **arises** from the whole posterior surface of the humerus below the spiral groove, from the lower part of the external intermuscular septum, from the whole of the internal, as high as the teres major; some of its fibers are **inserted** directly into the olecranon process of the ulna, but most join the deep surface of the tendon. The **common tendon is inserted** into the tuberosity of the olecranon process of the ulna, and externally a band is prolonged over the anconeus to the fascia of the forearm and posterior border of the ulna; it may send a slip to the capsule.

Muscles and Fasciæ of the Forearm

The **superficial fascia** is most distinct at the elbow, contains the superficial veins, and below connects the skin with the palmar fascia.

The **aponeurosis** of the forearm (deep fascia) is composed largely of transverse fibers, strengthened by expansions from the condyles of the humerus, olecranon, and fascia over the biceps and triceps. It sends in a thin layer between the superficial and deep muscles; this anterior portion of the fascia forms at the wrist the anterior annular ligament, which binds down the tendons of the flexor muscles. The *posterior portion* sends off septa between the muscles and forms the posterior annular ligament, which firmly holds in position the tendons of the extensor muscles. The tendon of the palmaris longus muscle is the only one passing in front of the anterior annular ligament.

The Anterior Radioulnar Region.—These muscles are described as a superficial set, consisting of five; and a deep group, of three.

Superficial Layer.—All from a common tendon in the following order from without in:

Pronator teres **arises** by two heads, the larger from the upper part of the inner condyle above the common tendon and from the common tendon, fascia, and intermuscular septum; second head, thin and deep, from the inner margin of the coronoid process; **insertion,** by a flat tendon on the middle of the outer surface of the radius. The ulnar artery is beneath this muscle, and the median nerve between its heads.

Flexor carpi radialis **arises** from the common tendon, fascia of the forearm, and septa between it and the pronator teres, palmaris longus, and flexor sublimis; tendon begins below the middle of the forearm, passes through a special compartment of the anterior annular ligament through a groove in the trapezium; **inserted** into the base of the second metacarpal bone, anterior surface, and usually by a small slip to the base of the third.

Palmaris longus is placed between the ulnar and radial flexors of the carpus, resting upon the flexor sublimis; **arises** from the common tendon, fascia, and septa,

Fig. 68

Superficial muscles of front of right forearm. (Testut.)

forming a short muscular belly ending in a slender tendon, **inserted** into the palmar fascia, and sends a slip to the abductor pollicis, sometimes one to the little finger muscle.

Flexor carpi ulnaris (M. ulnaris internus) is the innermost of the superficial group; **arises** by two heads, one from the common tendon, and one from the inner side of the olecranon and upper two-thirds of the posterior border of the ulna by an aponeurosis common to it, the flexor profundus digitorum and the extensor carpi ulnaris; muscular fibers end in a tendon which occupies the anterior margin of the lower half of the muscle; posteriorly the muscular fibers continue down to within an inch of its insertion; **inserted** into the pisiform by a small band to the anterior annular ligament.

Flexor sublimis digitorum, placed behind the preceding, **arises** by three heads: (1) Inner condyle by the common tendon, fibrous septa, and internal lateral ligament; (2) internal margin of the coronoid;

(3) anterior oblique line of the radius; divided below into four parts, ending in tendons **inserted** into the second phalanges of the four inner digits.

THE DEEP MUSCLES.—*Flexor profundus digitorum.* —**Origin,** the upper three-fourths of the inner and anterior surface of the ulna, from not quite the ulnar half of the interosseous membrane for the same distance, and from an aponeurosis attached to the posterior border of the ulna, common to it, the flexor and extensor carpi ulnaris. Only one tendon (for the index finger) separates above the wrist; in the palm, as the tendons diverge, they give origin to the lumbricales; over the first and second phalanges the tendon is bound down by an osseo-aponeurotic sheath, and opposite the first phalanx it passes through an opening in the flexor sublimis tendon, and is finally **inserted** by an expanded end into the base of the third or last phalanx.

The **sheaths of the flexor tendons** are opposite the first and middle phalanges, and formed of strong transverse bands, *ligamenta vaginalia;* opposite the joints the bands change into a thin membrane, strengthened by oblique decussating fibers, so that there are *annular* or *transverse* fibers, and *crucial* or *oblique.* The sheath has a synovial lining containing small folds, **vincula tendinum** or **ligamenta mucosa,** passing between the tendons and bones.

Flexor longus pollicis **arises** from the **anterior surface** of the radius, below its oblique line to the edge of the pronator quadratus, and from the adjacent part of the interosseous membrane. The tendon passes between the sesamoid bones of the thumb and enters a canal similar to that of the other flexors, to be **inserted** into the base of the last phalanx of the thumb. Its complete separation from the flexor profundus is characteristic of man.

Pronator quadratus, just above the wrist, close to the bones behind the last two muscles, quadrilateral and flat, arises from the pronator ridge and inner part

of the anterior surface of the ulna for the lower fourth, and from the inferior from the radiocarpal joint; **inserted** into the anterior surface and anterior margin of the shaft of the radius for a little less than its fourth.

The Radial Region.—Three in number, from the lower third of the arm and upper third of the forearm in an almost continuous row.

Supinator longus **rises** from the upper two-thirds of the external supracondylar ridge of the humerus and external intermuscular septum, limited above by the spiral groove; thin fleshy belly ends at the middle of the forearm in a flat tendon which expands at its **insertion** into the outer side of the radius at the base of the styloid process.

Extensor carpi radialis longior **arises** from the lower third of the external supracondylar ridge and external intermuscular septum and a few fibers from the common tendon; **inserted** into the radial half of the posterior surface of the base of the second metacarpal.

Extensor Carpi Radialis Brevior.—**Origin,** by the common extensor tendon from the outer condyle, septa, external lateral ligament, fascia, and a fibrous arch over the radial nerve and radial recurrent vessels; **insertion,** into the radial half of the posterior surface of the base of the metacarpal bone of the middle finger.

The Posterior Radioulnar Region. — SUPERFICIAL LAYER.—*Extensor Communis Digitorum.*—**Origin,** common extensor tendon from the external condyle of the humerus, orbicular ligament, fascia, and septa; there are three fleshy bellies, the innermost divided into two, four passing under the posterior annular ligament; the first and second pass to the index and middle fingers connected by a weak band, always transverse; the first is joined by the extensor indicis tendon at the metacarpophalangeal joint; the third runs to the ring finger and sends a slip to the middle finger tendon; the fourth divides, the outer larger part going to the ring finger, the inner part joining the outer division

of the extensor minimi digiti tendon; this fourth is the smallest tendon, and receives muscular fibers as far as the wrist.

Opposite the metacarpophalangeal joints the tendons are bound down by transverse fibers from the front of the joint, ligamenta dorsalia; **inserted** into the base of the last phalanx.

Extensor minimi digiti **arises** from the superficial and deep fascia of the forearm, from the orbicular ligament, from the septa between it and common and ulnar extensors; its tendon is in a groove between the radius and ulna, and splits into two on the back of the hand, the outer being joined by a slip from the fourth common extensor tendon, and both parts **end on** the little finger, like the other extensor tendons.

Extensor Carpi Ulnaris (*Ulnaris Externus*).—**Origin,** common tendon, orbicular ligament, septa, fascia of the forearm, which is connected with the elbow-joint capsule, and anconeus. **Insertion,** tuberosity of the base of the fifth metacarpal. A bursa is under its tendon of origin in one-fourth of the cases.

Anconeus fills the space between the triceps and extensor carpi ulnaris; is flat and triangular, covered by fascia connected with the triceps; **arises** by a narrow tendon from a fossa on the inner and posterior part of the external condyle; upper fibers are transverse, the rest pass obliquely down and into the radial aspect of the olecranon and adjacent upper third of the ulna.

Deep Layer.—*Supinator Brevis.*—**Origin,** external lateral ligament, orbicular ligament, supinator ridge, oblique line of the ulna, and for a short distance on the outer border of the ulna from the fascia covering it, which is connected with the external condyle; it regularly consists of two layers separated by the posterior interosseous nerve; the superficial one rises by aponeurotic fibers, the other by muscular. The fibers pass sling-like around the upper part of the radius to be inserted into a third of its length, limited

by the anterior and posterior oblique lines to its neck and elbow-joint capsule.

Extensor Ossis Metacarpi Pollicis.—**Origin,** upper part of the outer division of the posterior surface of the ulna below the supinator brevis, from the middle third of the posterior surface of the radius and interosseous membrane between. Its tendon passes over those of the radial extensors, and is **inserted** into the radial side of the base of the metacarpal bone of the thumb, and commonly by a slip into the trapezium, its tendon usually splitting.

Extensor longus pollicis **arises** below the extensor ossis on the middle third of the ulna and from the interosseous membrane for about one inch; its tendon passes over the radial extensors, and is **inserted** into the posterior aspect of the base of the last phalanx of the thumb.

Extensor Indicis Proprius.—**Origin,** from the ulna below the extensor longus pollicis, and slightly from the interosseous membrane and fascia over the extensor carpi ulnaris; unites with the common extensor tendon for the index, and forms the usual **insertion.** This and the extensor minimi digiti tendon are always on the ulnar side of the respective common extensor tendons.

Extensor Brevis Pollicis.—**Origin,** small part of the interosseous membrane and radius below the middle, next below the extensor ossis; **insertion,** upper end of the first phalanx of the thumb on its posterior aspect.

The Muscles and Fasciæ of the Hands

Fascia of the posterior aspect is a thin layer prolonged from the posterior annular ligament and blending with the extensor expansions over the fingers; deeper than this the interossei are covered by thin aponeuroses.

Fascia of the palm consists of a strong central part and two lateral portions which cover the short

muscles of the thumb and little finger. The central portion is the part commonly called the *palmar fascia;* it consists of fibers mostly prolonged from the palmaris longus, some from the annular ligament, thus forming two superficial layers with vertical fibers, between which is the palmaris brevis muscle; there is a deep layer of transverse fibers. Below, the fascia divides into four processes to join the digital sheaths; offsets are sent back to the deep transverse ligament at the heads of the metacarpals, forming a short canal above each finger for the flexors. Between the processes the transverse layer of fascia covers the lumbrical muscles, digital vessels, and nerves, passing over to the thumb and forefinger. At the clefts of the fingers a transverse band is called the *superficial transverse ligament,* or Gerdy's fibers. The interossei muscles also have a separate fascia continued below into the deep transverse ligament.

The Radial Region.—The following muscles constitute the *thenar eminence* (the fleshy prominence of the palm corresponding to the base of the thumb) and have a great variety of description.

Abductor pollicis.	Adductor pollicis obliquus.
Flexor brevis pollicis.	Adductor transversus pollicis.
Opponens pollicis.	

The Ulnar Region.—The following muscles constitute the *hypothenar eminence.* (The fleshy prominence of the palm corresponding to the fleshy part over the metacarpal bone of the little finger.)

Abductor minimi digiti.	Opponens minimi digiti.
Flexor brevis minimi digiti.	Palmaris brevis.

The Middle Palmar Region.—The *dorsal interossei* are four in number, one for each space, not rising above the level of the bones, and numbered from without inward. Each rises from the two bones

between which it is placed, most extensively from that supporting the finger upon which it acts. The tendon is inserted partly into the base of the first phalanx and partly into the extensor tendon.

The *palmar interossei* are three in number, are adductors, and each rises from the lateral surface of the metacarpal of the finger on which it acts. They terminate like the posterior tendons. The first belongs to the ulnar side of the index, the second and third to the radial sides of the ring and little fingers.

The *lumbricales* are four small muscles, not always well-defined. They arise from the tendons of the flexor profundus digitorum.

Actions of Muscles of the Forearm and Hand.—*Pronation* by the pronator teres and quadratus and flexor carpi radialis slightly; pronator teres flexes the forearm; can only pronate when the radius is intact.

Supination by the supinator brevis, biceps, and supinator longus; the latter is a *flexor of the elbow* and brings the forearm into midsupination. *Radial extensors* of the wrist flex the elbow; others from the external condyle extend.

Flexion of the wrist by the flexor carpi ulnaris and radialis, by the flexors of the fingers and palmaris longus.

Extension of the wrist by the extensor carpi ulnaris, the two radial extensors, and extensors of the fingers.

Abduction of the wrist by the radial flexor and radial extensors and extensors of the thumb.

Adduction of the wrist by the flexor and extensor carpi ulnares. The flexor carpi radialis and extensor carpi ulnaris act on the radiocarpal joint; the flexor carpi ulnaris and radial extensors on the midcarpal joint.

The extensors of the wrist are moderators of the long flexors of the fingers; the flexors of the wrist are moderators of the extensors of the fingers.

The posterior interossei abduct the fingers from the middle one; the palmar adduct; the interossei and lumbricales flex the first phalanx and extend the last two.

Flexion in the fingers.	Extension in the fingers.
First phalanx, by the interossei and lumbricales.	By the extensor communis.
Second phalanx, by the flexor sublimis.	By the interossei and lumbricales.
Third phalanx, by the flexor profundus.	By the interossei and lumbricales.

When we flex the fingers they tend to approach, due to the lateral ligaments and obliquity of the tendons.

The *palmaris longus* makes tense the palmar fascia, feebly flexes the forearm and wrist; all the muscles from the condyle feebly flex the forearm.

Palmaris brevis wrinkles the skin over the hypothenar eminence and protects the ulnar vessels and nerve from pressure when a foreign body is grasped.

Extension in the thumb is in the plane of abduction of the fingers, and its abduction is a movement forward. The action of its muscles and those of the little finger are indicated by their names; the flexors of the first phalanx in either case also extend the last, as the interossei would. The ulnar extensor and flexor of the carpus are moderators of the thumb extensors. There are three flexors of the wrist (including the palmaris longus) and three extensors, three flexors of the fingers and three extensors, three flexors of the thumb and three extensors.

THE MUSCLES AND FASCIÆ OF THE LOWER EXTREMITY

Fasciæ of the Thigh

The **superficial fascia** is continuous with that of other parts of the body.

The **deep fascia** or **fascia lata** is a strong membrane forming a continuous sheath around the limb. It descends on the gluteus medius as far as the upper border of the gluteus maximus, which muscle it encases, and over the great trochanter a great part of the muscle is inserted between its layers. From the forepart of the iliac crest to the outer tuberosity of the tibia is the *iliotibial band,* which receives the insertions of the tensor vaginæ femoris and gluteus maximus muscles.

The fascia lata has various deep processes; one is internal to the tensor vaginæ femoris on the surface of the vastus externus.

There are *external* and *internal intermuscular septa* inserted into the linea aspera.

The Gluteal Region (Buttocks)

Gluteus Maximus.—A quadrilateral, very coarse muscle. **Origin,** posterior fourth of the external lip of the iliac crest and rough surface between it and the posterior gluteal line, the last two pieces of the sacrum and first three of the coccyx, great sacrosciatic ligament, and aponeurosis of the erector spinæ.

The upper half and superficial fibers of the lower half are **inserted** into the fascia lata and continued into the iliotibial band; the deeper portion of the lower half into the gluteal ridge on the upper third of the shaft of the femur.

Gluteus Medius.—**Origin,** ilium between the crest, the posterior and middle curved lines, and from the fascia covering it; to **insert** on the outer surface of the great trochanter; a small bursa between the bone and tendon.

Gluteus minimus is covered by the preceding, and **arises** from the whole surface on the ilium between the middle and inferior curved lines, fibers converge into an aponeurotic tendon on the outside of the muscle,

inserted into an impression on the front of the great trochanter.

Actions of the glutei on the lower limb:

Flexion.	Extension.
Glut. med., anterior fibers. Glut. min., anterior fibers.	Glut. maximus. Glut. med., posterior fibers. Glut. min., posterior fibers.
Adduction.	**Abduction.**
Glut. med., anterior fibers (in sitting posture. Glut. min., anterior fibers (in sitting posture).	Glut., max., slight. Glut. med. } Glut. min. } strong, whole muscle, especially mid-portion.
Rotate in.	**Rotate out.**
Glut. med., anterior fibers. Glut. min., anterior fibers.	Glut. max. Glut. med., posterior fibers. Glut. min., posterior fibers.

The *gluteus maximus* extends the trunk on the thigh as in ascending stairs; in walking it is not used, as the erect position is maintained by ligaments; steadies and supports the knee by the iliotibial band.

The *iliopsoas* flexes the thigh and rotates out; flexes the body on the thigh; the psoas bends the lumbar spine forward and laterally.

Psoas parvus makes tense the iliac fascia.

The Thigh Muscles

These are arranged in three sets—anterior, posterior, and internal, with superficial and deep layers, the former passing over two joints, the latter over one.

The Anterior Femoral Region.—*Tensor vaginæ femoris* (tensor fasciæ) lies in a groove between the gluteus medius, rectus, and sartorius. **Origin,** anterior part of the external lip of the iliac crest, notch between the two spines; **insertion,** between the two layers of the fascia lata three or four inches below the great trochanter, and from the insertion fibers are prolonged into the iliotibial band.

Sartorius (*Tailor Muscle*).—**Origin**, anterior superior spine of the ilium and small part of the notch immediately below; **insertion**, inner surface of the tibia near the tubercle, sending an expansion from the upper border to the capsule, one from the lower border to the fascia of the leg, and one to the tibia behind the tendons of the gracilis and semitendinosus.

Quadriceps Femoris.—Largest muscle of the body, four parts closely united. (*a*) *Rectus femoris*, in a straight line from the pelvis to the patella. **Origin**, by two heads, anterior one from the anterior inferior spine, and posterior from the impression just above the acetabulum; they join at an angle of 60 degrees close below the acetabulum; the tendon is anterior above, then in centre of the muscle. The lower tendon becomes free three inches above the patella; is attached to the upper margin of that bone, and helps form the common tendons.

(*b*) The *vastus externus* is the outer part of the quadriceps. **Origin**, narrow and aponeurotic from the upper half of the anterior intertrochanteric line, outer part of the root of the great trochanter, outer side of the gluteal ridge, upper half of the outer lip of the linea aspera, from external intermuscular septum, and a strong aponeurosis extending over the upper two-thirds of the muscle. Aponeurosis of insertion occupies the deep surface of the muscle, joins the common tendon, and sends expansion to the lateral patellar ligaments and rectus tendon.

(*c*) The *vastus internus* **arises** from a superficial aponeurosis and deeper fibers from the spiral line, inner lip of the linea aspera, and from tendons of the adductor longus and magnus; they end in a deep aponeurosis which enters the common tendon. Its muscular fibers pass lower than those of the externus, and are inserted into the inner margin of the patella, some into the rectus tendon.

Crureus **arises** from upper two-thirds of the anterior

surface of the femur, outer surface of the femur in front of and below the vastus externus, lower half of the external intermuscular septum; fibers end in a superficial aponeurosis which forms the deepest portion of the common tendon. They arise from a series of transverse arches with intervening bare spaces on the front of the femur. Between the crureus and the vastus internus most of the internal surface of the bone is free.

The *common* or *suprapatellar tendon* is **inserted** into the forepart of the upper border of the patella, and a few fibers are prolonged over its anterior surface into the ligamentum patellæ. A large, thick ligament surrounding the patella and inserted into the tubercle of the tibia.

Subcrureus is the name of a few fibers which may be regarded as the deepest layer of the crureus. **Origin,** anterior surface of the femur in the lower fourth; **insertion,** separated by a fat layer from the vasti into the synovial membrane of the knee-joint.

Hunter's canal is a three-cornered passage in the middle two-fourths of the thigh, in the angle between the adductors magnus and longus and vastus internus. It is made a canal by a bridge of fascia, and contains the femoral artery, vein, and long saphenous nerve.

Nerves.—Anterior crural for the quadriceps and sartorius; superior gluteal for the tensor vaginæ femoris.

Actions.—*Satorius* flexes the hip and knee with eversion of the thigh; rotates the leg inward.

Quadriceps femoris extends the leg; not necessary for the maintenance of the erect attitude.

Rectus femoris also flexes the hip; its posterior head is tense when the thigh is bent. Lower fibers of the vastus internus draw the patella in.

Tensor vaginæ femoris rotates the thigh in and abducts, assisted by the gluteus maximus; counteracts the gluteus maximus, which tends to draw the iliotibial band backward.

The Posterior Femoral Region (**Hamstrings**).—*Biceps Femoris.*—**Origin,** *long head* by a tendon common to it and semitendinosus from inner impression on the lower part of the ischial tuberosity, and from the sacrosciatic ligament; *short* head from the lower two-thirds of the outer lip of the linea aspera and external intermuscular septum; fibers from both heads end in a tendon **inserted** into the upper and outer part of the head of the fibula by two portions embracing the external lateral ligaments.

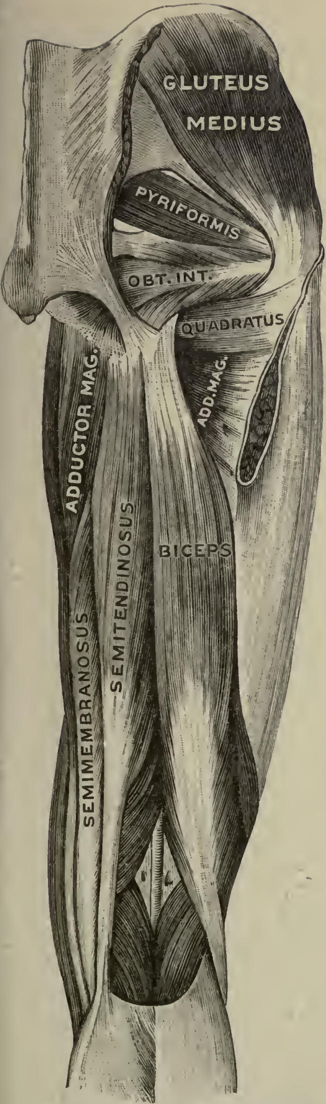
Semitendinosus.—**Arises** from the tuberosity of the ischium and tendon common to it and biceps for 3 inches. Terminates in the lower third of the thigh in a long, slender tendon, and curves forward in an expanded form to **insert** on the upper part of the inner surface of the tibia or anterior crest of the tibia, and sends a process to the fascia of the leg.

Semimembranosus.—**Origin,** tuberosities of the ischium above and outside the tendon of the biceps and semitendinosus, and its tendon is grooved posteriorly for the common tendon of those two muscles. Tendon of origin is on the outer side of the muscle for three-fourths the length of the thigh; tendon of **insertion,** on the opposite side of the muscle, and turns forward and is inserted by four parts: (1) into a horizontal groove on the back of the inner tuberosity of the tibia; (2) expansion is sent up and in as the posterior oblique ligament of the knee-joint; (3) down to the fascia over the popliteus muscle; (4) to form the short internal lateral ligament of the knee-joint.

The Internal Femoral Region.—*Pectineus.*—**Origin,** iliopectineal line, and slightly from bone in front of this, and from the fascia over the muscle; **insertion,** femur behind the small trochanter and upper part of the line passing from this trochanter to the linea aspera.

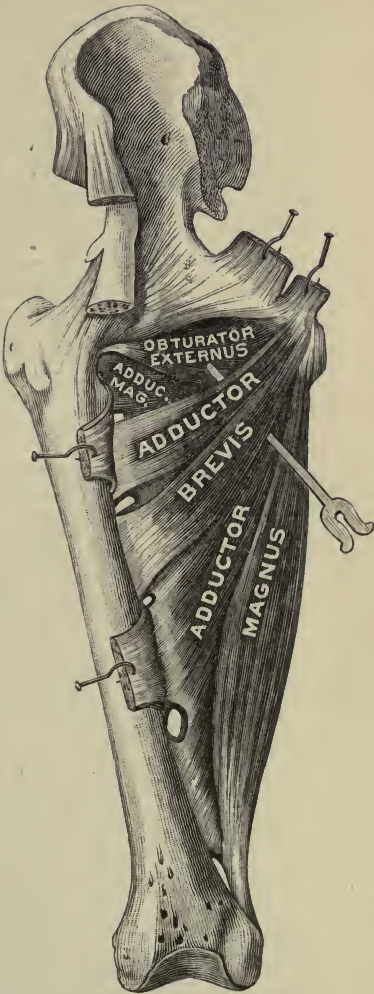
Adductor Longus.—Flat and triangular, internal to the pectineus, on same plane. **Origin,** short tendon

Fig. 69



Muscles in the dorsum of the right thigh. (Testut.)

Fig. 70



Adductores magnus and brevis of the right side. (Testut.)

from the body of the pubis below the crest and near the angle; **insertion**, inner lip of the linea aspera, united to the vastus internus in front and adductor magnus behind.

Gracilis.—**Origin,** inner margin of pubic bone and a portion of its inferior ramus; thin and flat, then narrow and thicker. A round tendon in the lower third of the thigh, curving forward below, **inserted** into the inner side of the tibia just above the semitendinosus, and covered by the sartorius.

Adductor Brevis.—**Origin,** body and inferior ramus of the pubis below the adductor longus, between the gracilis and obturator externus; **insertion,** into the whole line from the small trochanter to the linea aspera behind the pectineus. It lies between the adductor magnus and longus.

Adductor Femoris Minimus.—This is what is described with the adductor magnus, usually as its anterior and superior portion. **Origin,** body of the pubis and ischiopubic rami; **insertion,** femur, in a line from the quadratus femoris to the upper end of the linea aspera, and a short distance along it.

Adductor Magnus.—**Origin,** ischial ramus internal to the above muscle and outer half of the triangular space on the posterior inferior surface of the tuberosities of the ischii; fibers pass in two layers, one to the inner lip of the linea aspera, and the other on the inner side of the opening for the femoral vessels by a distinct rounded tendon to **insert** on the adductor tubercle on the inner condyle of the femur. The femoral attachment is interrupted by three or four tendinous arches for the perforating arteries.

Actions.—All adduct the thigh. *Pectineus, adductor longus* and *brevis* flex the hip, while part of *adductor magnus* from the ischial tuberosity to the condyle may extend the thigh and rotate in. *Gracilis* flexes the knee and rotates the leg inward. Adductors and opponens, the gluteals, balance the body in walking.

(1) Anterior fibers of the gluteus medius (2) and minimus; (3) tensor vaginæ femoris; and some say (4) the condylar part of the adductor magnus, rotate the thigh inward.

Muscles of the Leg

The Anterior Tibiofibular Region (Extensors).—*Tibialis Anticus.*—**Origin,** outer tuberosity of the tibia, upper half of the outer surface of that bone, and adjacent interosseous membrane, fascia of the leg, and intermuscular septum; **insertion,** oval mark on the inner and lower part of the internal cuneiform and first metatarsal dividing into two slips.

Extensor Longus or Proprius Hallucis. — **Origin,** middle two-fourths of the narrow anterior surface of the fibula and contiguous portion of the interosseous membrane; **insertion,** base of the terminal phalanx of the great toe on the dorsal aspect. It spreads in an expansion on each side over the metatarsophalangeal articulation, and almost always sends a slip to the base of the first phalanx.

Extensor Longus Digitorum Pedis.—**Origin,** external tuberosity of the tibia, head, and upper two-thirds of the anterior surface of the fibula, very largely from the septa and fascia and interosseous membrane above the origin of the extensor proprius hallucis. Tendon divides into four slips for the outer four toes. They are continued into expansions which are joined on the first phalanx by processes from the interossei and lumbricales. They divide into three parts—the middle **inserted** into the middle phalanx; the lateral parts unite, and are inserted into the base of the terminal phalanx as in case of the extensors of the fingers.

Peroneus Tertius.—**Origin,** lower third or more of the anterior surface of the fibula, from the interosseous membrane, from the septum between it and the

peroneus brevis; **insertion,** upper surface of the base of the fifth metatarsal, sometimes the fourth. This muscle is peculiar to man.

The Fibular or Peroneal Region.—*Peroneus Longus.*—**Origin,** head and upper two-thirds of the external surface of the fibula, fascia of the leg, and septa on each side. Tendon begins in the lower half of the leg, passes behind the external malleolus; then forward on the outer side of the os calcis, winds around the tuberosity of the cuboid, and enters its groove, crosses the sole obliquely, and is **inserted** into the outer side of the tuberosity of the first metatarsal, and slightly into the internal cuneiform; a frequent offset to the base of the second metatarsal and first dorsal interosseous.

Peroneus Brevis.—It lies deeper than the peroneus longus. **Origin,** lower two-thirds of the external surface of the fibula from the septa and a flat tendon on the surface turned toward the bone; **insertion,** tuberosity at the base of the fifth metatarsal, sending a small slip to the outer edge of the extensor of the little toe or forepart of the metatarsal bone.

The Posterior Tibiofibular Region (Flexors).—*Superficial Muscles.*—*Gastrocnemius.*—Gastrocnemius has two large heads from the femur, **terminating** at the middle of the leg in a common tendon. *Outer* head **from** the depression on the outer side of the external condyle above the tuberosity, and from the posterior surface of the femur just above that condyle. *Inner* head **from** the upper part of the internal condyle. The two heads join with the soleus and are inserted into the tendo Achillis.

Soleus.—**Origin,** externally from the posterior surface of the head and upper third of the shaft of the fibula; internally, oblique line and inner border of the tibia to its middle, and from a tendinous arch over the popliteal vessels and nerve; fibers rise to a large extent from two tendinous laminæ which descend

in the muscle, one from the fibula and one from the tibia. Fibers from the anterior surfaces of these laminæ converge to a median septum; fibers from their posterior surfaces pass down and back to an aponeurosis covering the back surface of the muscle. The **tendon of insertion** is prolonged from this aponeurosis, joined by the median septum. Muscular fibers are continued down on the deep surface of the tendo Achillis near to the heel.

The gastrocnemius and soleus form the calf of the leg.

Tendo Achillis, broad at first, contracts to within $1\frac{1}{2}$ inches of the heel, then expands, and is inserted into the middle and lower parts of the posterior surface of the tuberosity of the os calcis, a bursa having all the characters of a synovial membrane, with vascular and fatty synovial tufts, separating it from the upper part of this surface.

Plantaris.—**Origin,** femur above the external condyle and from the posterior ligament of the knee-joint. Muscular belly 3 to 4 inches long, and the long, slender tendon turns in between the gastrocnemius and soleus to the inner border of the tendo Achillis, and **inserted** by its side into the os calcis.

Popliteus.—**Origin,** round tendon, one inch long, from the groove on the outer surface of the external condyle of the femur, within the capsule of the joint, in contact with the semilunar cartilage, and by muscular fibers from the ligamentum popliteus arcuatum. Fibers pass down and are **inserted** into the triangular surface of the tibia above the oblique line, and into the aponeurosis over the muscle.

THE DEEP MUSCLES (*Flexors*).—*Flexor Longus Digitorum Pedis.*—**Origin,** inner portion of the posterior surface of the tibia for the middle two-fourths of its length, from the aponeurosis over the tibialis posticus. Descends behind the internal malleolus of the tibia, passes forward and obliquely outward, having crossed the tibialis posticus tendon in the leg, and now crossing

that of the flexor longus hallucis, in each case superficially. It divides into four parts **for** terminal phalanges of the four lesser toes.

Tibialis Posticus, beneath the two long flexors. **Origin,** posterior surface of the interosseous membrane, outer part of the posterior surface of the tibia below the oblique line of the middle of the bone, whole inner surface of the fibula, and from the aponeurosis over it. Tendon along the inner border of the muscle, free at the level of the lower tibiofibular articulation, passes behind the inner malleolus, **inserted** into the tuberosity of the scaphoid, with offsets to the three cuneiform, to cuboid, to bases of the second, third, and fourth metatarsals, and to the transverse tarsal ligament and flexor longus hallucis tendon, and sends a thin process back to the sustentaculum tali of the os calcis.

Flexor Longus Hallucis.—**Origin,** lower two-thirds of the posterior surface of the fibula, septum between it and the peronei; aponeurosis common to it and flexor longus digitorum. Tendon at the posterior surface of the muscle traverses groove on the back of the astragalus and under surface of the sustentaculum, gives slip to the flexor longus digitorum in the sole of the foot, and proceeds to the base of the terminal phalanx of the great toe.

Muscles of the Foot

The Dorsal Region (Instep).—*Extensor Brevis Digitorum Pedis.*—**Arises** from forepart and upper and outer surface of the os calcis, in front of the groove for the peroneus brevis tendon, and from the anterior ligament of the ankle. The tendon has several vertical leaflets from which muscular fibers arise, dividing into three bellies which unite with the outer border of the long extensors for the second, third, and fourth toes.

The Plantar Region (Sole).—THE CENTRAL GROUP.—*Flexor Brevis Digitorum and Flexor Accessorius Lumbricales.*—Four in number. **Origin,** at points of division

of the flexor longus digitorum tendon, each attached to two tendons, except the most internal one; they pass to the inner side of the four outer toes; **inserted** into the bases of the first phalanges.

The Internal Group.—*Abductor Hallucis,* flexor brevis hallucis, and adductor hallucis (oblique transverse portions).

The External Group.—*Abductor Minimi Digiti,* and flexor brevis minimi digiti.

Actions.—*Popliteus* flexes the knee and rotates the leg inward, pulls on the capsule of the joint, and keeps the popliteal bursa open. The dorsum of the foot and anterior surface of the leg is the *extensor surface;* the opposite side is the *flexor surface,* so that raising the foot toward the front of the leg is really extension, and depressing it is flexion; it is customary to apply reverse terms to these acts.

Gastrocnemius flexes the knee, extends the ankle, combines with the soleus, and lifts the heel or raises the body on toes.

Tibialis anticus and *peroneus tertius* flex the ankle; the former rotates inward, adducts, raises the first metatarsal bone.

Tibialis posticus, peroneus longus and *brevis* are extensors of the ankle-joint. Tibialis posticus and flexors of the toes rotate the foot in. The three peronei and extensors of the toes rotate outward.

Peroneus longus strengthens the transverse arch, lifts the outer border of the foot in walking, extends the foot, depresses the first metatarsal, abducts the forefoot, rotates outward.

Flexors and extensors of the toes, interossei, and lumbricales act as do the corresponding muscles of the hand.

Flexor accessorius modifies the action of the flexor longus digitorum, as those tendons cannot enter the foot in a straight line.

The *extensor brevis digitorum* does the same for the

extensor communis, though here they are not so much needed, and their function is not so evident.

Extensors of the foot slightly rotate inward; flexors of the foot slightly rotate outward; *plantaris* indirectly pulls up the capsule of the ankle-joint and slightly aids the gastrocnemius.

Flexors of the foot.	Extensors of the foot.
Tibialis anticus. Extensor communis digitorum. Extensor proprius hallucis. Peroneus tertius.	Tendo Achillis. Peroneus longus and brevis. Tibialis posticus. Flexor longus digitorum and hallucis.
Adduction.	**Abduction.**
Tibialis posticus (strongly). Tendo Achillis (weakly). Perhaps tendons behind the inner malleolus, perhaps the tibialis anticus.	Peroneus brevis. Peroneus longus.
Rotation in.	**Rotation out.**
Tibialis anticus (strongly). Tendo Achillis.	Peroneus longus. Extensor communis digitorum. Peroneus tertius.

The Interosseous Muscles.—*Interossei*, as in the hand, are seven in number, four dorsal and three plantar. The dorsal project downward as low as the plantar, and alternate with them. Only one muscle in the first space, two in the others. The second phalanges are their centre of insertion.

QUESTIONS

1. Name the three varieties of muscle tissue.
2. What does the sarcoplasm represent in muscle tissue?
3. Does the sarcoplasm possess the quality of contractility?
4. What do you understand by a skeletal muscle?
5 What forms the fibers in a muscle? The primary bundles? Secondary?
6. What is the function of the epimysium? Perimysium? Endomysium?
7. Where are voluntary striated muscles found in the body? Involuntary non-striated?

8. Where is involuntary striated muscle found?
9. What influences the consistency of a muscle?
10. What effect do irritating stimuli have upon muscles?
11. What stimulus causes muscle to contract in the living body?
12. Name some of the artificial and experimental stimuli for muscles.
13. What is the function of a tendon? An aponeurosis?
14. What structure of bones receives the attachment of muscles?
15. Give the names applied to the parts of a muscle.
16. What do you understand by the origin of a muscle? Insertion?
17. Do most muscles act from either their origin or insertion?
18. How do muscles derive their names in the living body?
19. What variety of tissue forms tendons? Aponeuroses?
20. What are tendons attached to?
21. With which shaped muscles are aponeuroses usually found?
22. Where is fascia usually found?
23. In the description of a muscle what must be included?
24. Name the muscles of mastication.
25. What muscles flex the forearm upon the arm?
26. Give action of the latissimus dorsi muscle.
27. What muscles fill up the intercostal spaces of the thorax?
28. Name the muscles which flex the fingers. Extend.
29. What muscles form the thenar eminence of the hand? Hypothenar?
30. Name the musculomembranous structure which separates the thorax and abdomen.
31. Give the origin and insertion of the following muscles: Biceps (arm). Sartorius. Supinator longus or brachioradialis. Tibialis anticus. Flexor longus hallucis. Rectus femoris. Palmaris longus.
32. Name the muscles which form in a general way the anterior abdominal wall.
33. What muscle surrounds the eye and gives it function?
34. Name the muscles which adduct the thigh.
35. What muscle covers the shoulder-joint on its outer side?
36. Give a brief description of the scalp. Of the fascia of the palm of the hand.

CHAPTER VIII

THE DESCRIPTION OF THE ANATOMY AND PHYSIOLOGY OF THE CIRCULATORY APPARATUS

The circulatory apparatus consists of the **heart**, covered by the pericardium, the **arteries**, **veins**, and **capillaries**, and circulating fluid—the **blood.**

THE PERICARDIUM

The *pericardium* is a serofibrous membrane which invests the heart and the great vessels at their origin for about two inches. The pericardium consists of a fibrous and serous layer, between which is a small amount of serous fluid, preventing friction, as at each rhythmic contraction of the heart these layers rub against each other. The serous layer (epicardium) invests the heart muscle and is reflected to the fibrous layer.

THE HEART

The *heart* is a hollow muscular organ situated in the thorax between the right and left lobes of the lungs, enclosed by the pericardial sac.

It lies obliquely, the base being directed upward, backward, and toward the right, its position corresponding to the surface of the chest wall extends from the fifth to the eighth thoracic vertebra. The apex looks downward, forward, and to the left, its

impulse against the chest wall being felt in the fifth interspace on the left side, about $3\frac{1}{4}$ inches from the middle of the sternum. The posterior or postero-inferior surface is flat, formed chiefly by the wall of the left ventricle, and rests on the diaphragm; its anterior or anterosuperior surface is convex, formed chiefly by the wall of the right ventricle, but also partly by the left, and is overlapped by the lungs, except in the central part. The borders of the heart are right and left, the former is long and thin, the left shorter and thicker. The length of the heart is about 5 inches, the greatest breadth $3\frac{1}{2}$ inches; its thickness about $2\frac{1}{2}$ inches. Its weight is approximately 10 to 12 ounces in the male, 8 to 10 ounces in the female, and these increase with age.

Externally its surface presents a deep transverse groove, auriculoventricular, which marks an upper auricular and lower ventricular portion; this latter part presents a longitudinal furrow on the front and the back, the former being somewhat to the left, the latter to the right, marking off the right and left ventricles (interventricular groove).

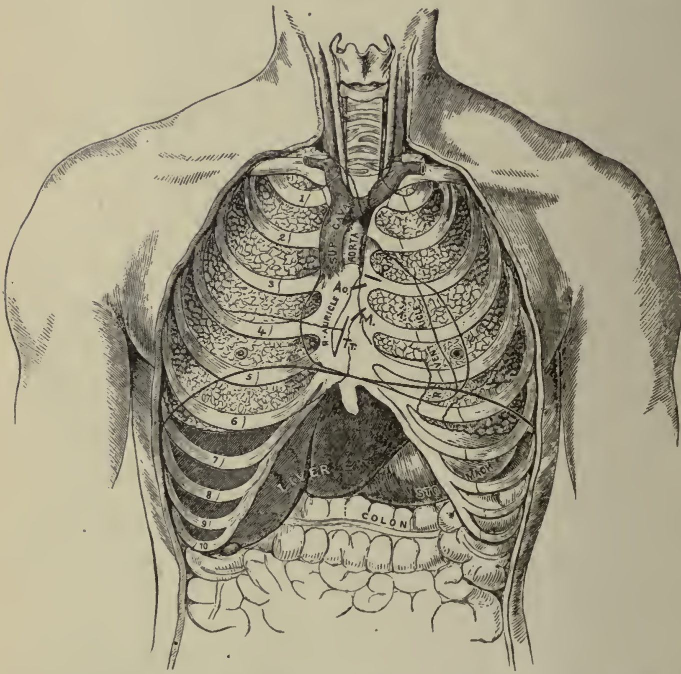
The heart contains four chambers. They are divided by a longitudinal partition or septum into a right and left part; and these in turn are subdivided into an auricle and a ventricle by a transverse partition, which is perforated on each side by an opening, called the auriculoventricular, connecting the auricle and ventricle

The Cavities of the Heart.—The inner surface of the heart muscle (myocardium) is lined throughout by a thin layer of membrane called the **endocardium.** It is continuous with the lining membrane of the great bloodvessels opening into the heart cavities, and helps to form the various valves by a process, whereby the membrane is thrown into folds. The endocardium consists of a flattened layer of endothelial cells resting on a membrane formed of subendothelial

(fibro-elastic) tissue. On opening the heart the following structures can be seen within its cavity:

The Right Auricle.—This is larger than the left, its wall being about one line in thickness and its capacity two ounces. Within the auricle the following parts present themselves for examination:

Fig. 71

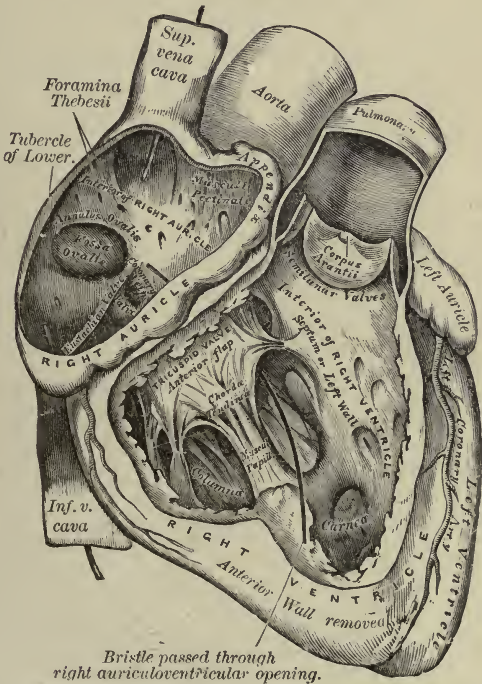


Front view of the thorax, showing relation of the heart and its valves, lungs, etc., to the ribs and sternum. *P*, pulmonary orifice; *Ao*, aortic orifice; *M*, left auriculoventricular orifice; *Tr*, right auriculoventricular orifice.

The *orifice of the superior vena cava,* looking downward and forward. The *orifice of the inferior vena cava,* at the lowest part, near the septum, looking upward

and inward. Between the two caval openings a projection, the *tubercle of Lower.* The *opening of the coronary sinus,* between the inferior cava and the auriculoventricular opening, and protected by the fold of endocardium forming the coronary valve. Numer-

FIG. 72



The right auricle and ventricle laid open, the anterior walls of both being removed. (Gray.)

ous small openings (*foramina Thebesii*) of the small veins of the heart. The *auriculoventricular opening,* between the auricle and ventricle. The *Eustachian valve,* between the front of the inferior vena cava

and the auriculoventricular orifice. It is semilunar in form, the free concave margin sending one cornu to join the front of the annulus ovalis and the other to the auricular wall. The *fossa ovalis,* at the back of the septum, in the situation of the fetal foramen ovale, its prominent margin being known as the annulus ovalis. The *musculi pectinati,* small elevated columns which traverse the appendix and the adjacent part of the sinus.

The Right Ventricle.—This is pyramidal, and extends nearly to the apex of the heart. It is bounded internally by the convex surface of the wall of the ventricles, and prolonged above and internally into a pouch, the infundibulum, or conus arteriosus, from which springs the pulmonary artery. Its cavity has a capacity of three ounces. On opening the ventricle the following parts are presented for examination:

The *auriculoventricular orifice,* oval in form, and placed near the right side of the heart. Around its circumference is a fibrous ring, and it is guarded by the tricuspid valve. The *opening of the pulmonary artery,* circular in form, at the summit of the conus arteriosus, near the septum; is guarded by the pulmonary valves (semilunar). The *tricuspid valve* consists of three triangular flaps formed of fibrous tissue covered by endocardium. They are continuous with one another at their bases, and their free margins and ventricular surfaces give attachment to the chordæ tendineæ. Their central part is thick and strong, the lateral margins thinner and flexible. The *chordæ tendineæ* are attached as follows: several to the attached margin of each flap, blending with the fibrous ring; several to the strong central part; and the finest and most numerous to the margins of each curtain. The *columnæ carneæ* are projecting bundles of muscular substance found all over the ventricular wall excepting the conus arteriosus. They afford attachment for the papillary muscles. The three *semilunar valves*

guard the pulmonary orifice. They are semicircular, their free margins being thick and tendinous, and presenting at the middle a small fibrous nodule, the corpus Arantii. On each side of this body, just behind the free margin, the valve presents a small thinned-out interval, and when the valves are closed during diastole these valves are in contact, and so also are the three nodules. These latter prevent any leakage from the triangular space which would otherwise be left. At the commencement of the pulmonary artery are three pouches, the *sinuses of Valsalva,* placed one behind each valve. They resemble those of the aorta, but are smaller.

The Left Auricle.—This is smaller and thicker walled than the right, and consists, like the right, of a sinus and an appendix. The latter overlaps the pulmonary artery. Within it presents the following features of interest:

The *orifices of the pulmonary veins,* opening two into the right and two into the left side (sometimes only three are seen); the *auriculoventricular orifice;* and a few musculi pectinati on the inner side of the appendix.

The Left Ventricle.—This is longer than the right, and forms the apex of the heart. Its walls are three times as thick as those of the right. Within it presents for examination:

The *auriculoventricular orifice,* which is smaller than the right and guarded by the mitral or bicuspid valve; and the aortic opening, in front and to the right of the preceding, guarded by the semilunar valves. The *mitral valve* is attached, like the tricuspid, on the right side. It consists of two curtains which are larger and thicker than those of the tricuspid, and of two smaller segments, one at each angle of junction of the former. They are furnished with chordæ tendineæ. The *aortic semilunar* valves are similar to but larger and stronger than the pulmonary

valves. *Columnæ carneæ* are found in the right ventricle, and the musculi papillares are very large; one is attached to the anterior wall, the other to the posterior.

See Fig. 71 for relation of the valves and orifices of the heart to the chest wall.

The **muscle fibers** of the heart are **attached to** cartilaginous rings which surround the auriculoventricular and arterial orifices.

Nerves.—(See pages 121, 383.)

THE CIRCULATION OF THE BLOOD

The heart is the pump which propels the blood, aided by the elasticity of the arteries, veins, and connecting capillaries throughout the body. Without the rhythmical contraction of the heart muscle, life cannot be maintained. The blood courses through the cavities of the heart as follows. Allowing that the heart has emptied its chambers, this blood is returned to the heart as venous blood through the superior and inferior vena cavæ which open into the right auricle, from which it passes to the right ventricle through the auriculoventricular opening. The blood now is forced into the pulmonary artery and its branches to the pulmonary capillaries in the lungs, where the blood, coming in contact with the air we breathe, by a process of gaseous exchange, gives up the carbon dioxide to the lungs, and absorbs oxygen, becoming bluish red or scarlet in color. This new or arterialized blood is carried back by the pulmonary veins to the left auricle of the heart, flows through the left auriculoventricular opening into the left ventricle and thence through the aorta to the small arteries coursing along until the capillaries are reached in every part of the body, when by the same gaseous exchange as we said occurred in the lungs, the blood gives up its oxygen to the tissues and absorbs the

PLATE III

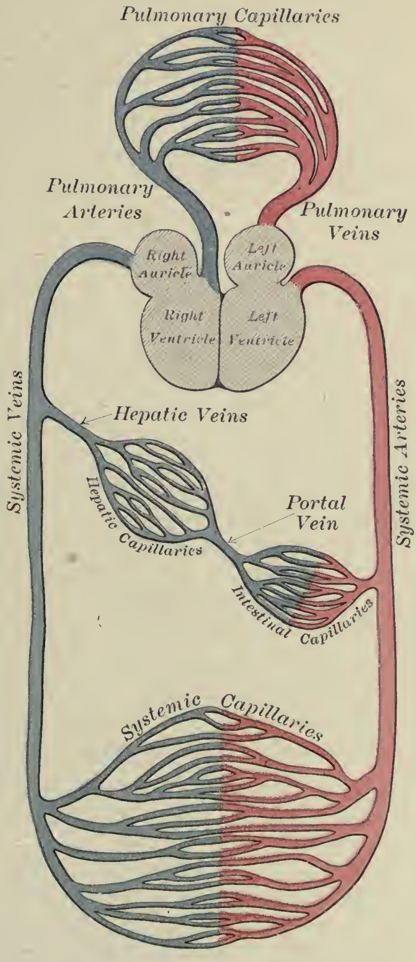


Diagram to Show the Course of the Circulation of the Blood.

This diagram does not show that the liver also receives blood through the hepatic artery.

carbon dioxide from them, and is changed from a scarlet to a *bluish* red color. The same venous return of the blood occurs to the right auricle and the cycle is repeated. It must be remembered that while the venæ cavæ are filling the right auricle, the pulmonary veins are at the same instant pouring their contents into the left auricle.

The blood is moved through the heart and blood-vessels by a continuous, rhythmic, and automatic contraction and relaxation of the heart muscle due to an inherent power possessed by the heart of converting potential energy stored up during the period of rest into kinetic energy, *i. e.,* heat and mechanic motion. The rhythmic contraction wave of the heart is carried on by means of a thin and distinct bundle of muscle fibers—the **bundle of His** or **atrioventricular.** It commences in the right auricle near the orifice of the Eustachian valve and passes to the wall between the ventricles to end in the papillary muscles of the ventricles. Disease or injury to these fibers causes an interference with the muscular contraction which begins in the auricle and extends to the ventricles. This leads to a condition which arises as a result of the auricle continuing to contract, and forces the blood into the ventricles, allowing the blood to be continuously pumped, while the ventricle not responding permits the blood to collect, due to its inability to contract. This condition is called **Adams-Stokes sign** or **heart-block** and is fatal. When any portion of the heart contracts it is called the **systole,** and relaxation, the **diastole.** The heart having two cavities on each side, when their walls contract and relax in succession we speak of an auricular systole and diastole, and a ventricular systole and diastole.

The contraction systole of the heart muscle starts as a wave in the great veins and then passes to the base of the heart in both auricles, and extends rapidly over the ventricles to the apex; during this period

the auricles and ventricles empty their cavities of blood into the pulmonary and arterial systems from the right and left sides of the heart respectively. Following this contraction wave is a pause or relaxation of the muscle—the diastole—during which time the blood rapidly flows into the auricles and ventricles, and at the end of the relaxation or diastole there is a period of rest, during which time the auricles and ventricles, or, in fact, the whole heart, is quietly filling with more blood, when the phenomenon is resumed.

The Part Played by the Heart Muscle and Valves during the Course of the Blood through the Chambers of the Heart.—We will start by allowing that the contraction or systole of the ventricle has occurred. Instantly the column of blood forced into the aorta and pulmonary artery, by filling the sinuses of Valsalva, forces the margins of the semilunar valves together and prevents the return of the blood to the ventricles from the aorta and pulmonary artery; while the ventricle contraction or systole was emptying its chambers, the auricles were filling from the venæ cavæ and pulmonary veins, and this blood was rapidly passed into the ventricles during the relaxation or diastole, while a new supply has taken its place in the auricles, the ventricles becoming distended with more blood (during the period of rest) force upward the tricuspid and mitral valves, gradually closing the auriculoventricular openings. Suddenly the auricles contract or begin their systole, and more blood is forced into the ventricles, the valves close; immediately the ventricular systole or contraction takes place, the blood not being able to pass back into the auricles owing to the closure of the auriculoventricular openings, is forced into the aorta and pulmonary artery, when the semilunar valves are flattened against the walls by the pressure from the blood in the ventricles. Now the ventricular systole is completed, the

semilunar valves are instantly closed to prevent a return of blood to the ventricles from the aorta and pulmonary artery; the period of rest occurs, following the emptying of the ventricles, and the cycle is repeated.

The Cardiac Cycle or Revolution.—This has been shown above to consist of (1) an auricular contraction, (2) ventricular contraction, (3) the period of repose, during which time the auricles and ventricles are at rest. There are 72 cycles per minute made by the heart of a healthy adult, and the average duration of each cycle is about eight-tenths of a second, divided as follows:

Auricular systole $\frac{1}{10}$	Auricular diastole $\frac{7}{10}$
Ventricular systole $\frac{3}{10}$	Ventricular diastole $\frac{5}{10}$

Common pause $\frac{4}{10}$

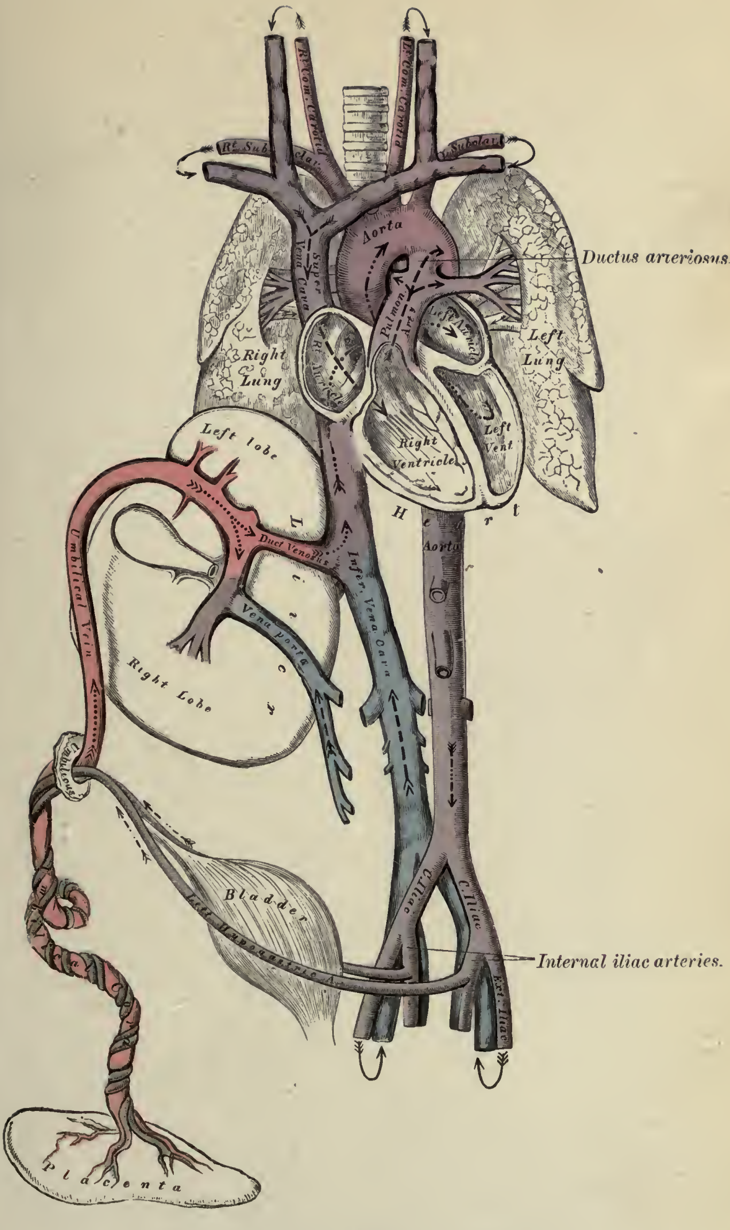
The Heart-beats.—In a healthy adult the pulsations or cardiac cycles are 72 per minute; in the fetus, 140 per minute; during the first year of life it decreases to 128 per minute; during the third year to 95 per minute; from the eighth to the fourteenth year, 84 per minute. It is more rapid in the female, averaging 8 to 10 more beats per minute. The pulse of a person lying down is a few beats less than when sitting or standing. Exercise and digestion temporarily increase the number of beats.

The Heart Sounds.—On placing the ear or the stethoscope to the chest wall overlying the heart, or in the fifth intercostal space, $3\frac{1}{4}$ inches from the middle of the sternum, two sounds resembling the pronouncing of the syllables lubb-dupp, lubb-dupp, will be heard. They accompany each pulsation of the heart and are called the first and second sounds; the former is dull and long, and occurs with the cardiac systole or contraction; the latter is short and clear and occurs at the commencement of diastole or relaxation of the heart muscle. The cause of the **first sound** is supposed to be due to the contraction of

the muscular walls of the ventricles, the gradual closure and vibrations of the mitral and tricuspid valves, and the sudden pressure of the apex against the chest wall. The **second sound** is supposed to be due to the sudden closure and vibrations of the semi-lunar valves in the aorta and pulmonary artery, following the ventricular systole or contraction; also the sound is added to by the whirling of the column of blood against those closed valves at the beginning of diastole or relaxation of the ventricles.

The Fetal Circulation.—The fetus is nourished by the blood from the placenta (afterbirth). The blood is conveyed from the placenta to the fetus by the umbilical vein. This vein enters the umbilicus and passes upward along the upper free margin of the suspensory ligament of the liver to the under surface of the liver. The blood after nourishing the organ by two or three branches, finally reaches the inferior vena cava by way of the hepatic veins, and the ductus venosus, which runs from the transverse fissure of the liver to open into the hepatic veins just before they open into the inferior vena cava. The superior and inferior vena cava open into the right auricle of the heart.

The course of the blood through the chambers of the fetal heart differs from that observed in the adult, viz., the blood from the inferior cava passes into the right auricle and then is directed by the Eustachian valve to the left auricle of the heart through the foramen ovale. In the left auricle the blood from the right auricle becomes mixed with a small quantity of blood returned from the lungs by the pulmonary veins. This blood then passes into the left ventricle (as seen in the adult) and then into the aorta, by which vessel it is distributed almost entirely to the head and upper extremities. The blood is returned from the head and upper extremities by the veins, which ultimately drain into the superior vena cava, that



Plan of the Fetal Circulation.

In this plan the figured arrows represent the kind of blood, as well as the direction which it takes in the vessels. Thus, arterial blood is figured >>—······—>; venous blood, >>—————>; mixed (arterial and venous) blood, >>···—···—>.

opens into the right auricle of the heart. From the right auricle the blood passes over the Eustachian valve into the right ventricle, then from the latter into the pulmonary artery. The lungs of the fetus being inactive, require only enough blood to develop and nourish them, this quantity of blood is conveyed by the pulmonary arteries and returned to the pulmonary veins to the left auricle; the greater quantity of blood from the right ventricle passes through the ductus arteriosus (a small vessel connecting the pulmonary artery with the aorta) into the beginning of the descending aorta, where it becomes mixed with the blood from the left ventricle.

The general distribution of blood through the body of the fetus is similar to the adult system, with the exception of the above-mentioned differences and the return of waste materials from the fetus to the placenta by way of the hypogastric arteries, which are branches of the internal iliacs and join the umbilical vein at the umbilicus (navel) to assist in forming the umbilical cord of the fetus.

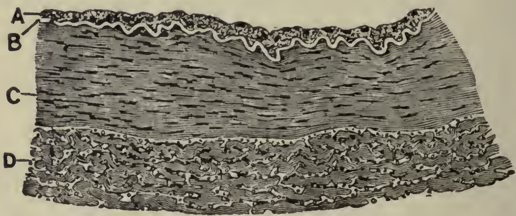
The Changes in the Circulatory Apparatus following Birth.—With the commencement of normal respiration (the umbilical cord being ligated), the placental circulation is cut off. Anywhere within ten days after birth the foramen ovale closes and may continue as a slight opening and not be injurious to health until the final closure. When the foramen does not close, the skin, etc., becomes cyanotic, due to the mixing of the arterial and venous blood—the so-called blue baby.

The umbilical vein, ductus venosus, and arteriosus atrophy, and also the hypogastric arteries. Thus the infant vascular apparatus assumes the normal course as described in the adult.

Structure and Functions of the Arteries, Veins, and Capillaries.—The Arteries.—These are closed tubes which convey the blood and keep it in circulation from the heart cavities throughout the body.

The typical artery consists of three coats: internal or tunica intima; middle or tunica media; an external or tunica adventitia. Aside from the latter, most arteries are covered by a sheath of connective tissue derived from the fascia of the part of the body in which they are found, and held to the artery by fibrous tissue.

Fig. 73



Transverse section of part of the wall of the posterior tibial artery. × 75. *A*, endothelial and subendothelial layers of inner coat. *B*, elastic layer (fenestrated membrane) of inner coat, appearing as a bright line in section. *C*, muscle layer (middle coat). *D*. outer coat, consisting of connective-tissue bundles. In the interstices of the bundles are some connective-tissue nuclei, and, especially near the muscular coat, a number of elastic fibers cut across. (Schäfer.)

The muscular tissue (media) is not so well-marked in the larger arteries, but the elastic tissue predominates and is more closely arranged; in the smaller arteries the elastic tissue is in excess, while only a single layer of muscle tissue is present; the larger arteries possess a thicker outer or fibrous coat than the smaller vessels.

All arteries possess elasticity and contractility due to the presence in their walls of the elastic (intima) and muscle (media) coats.

Elasticity.—This elastic property possessed by arteries permits their wall to expand and recoil to adapt itself to the pressure and reaction of the column of blood thrown into the arterial system from the ventricle of the heart at each contraction or systole and subsequent relaxation or diastole.

This elasticity of the arterial wall, in response to the pressure and reaction of the column of blood imparted to it by the heart muscle, develops into a remittent expansion and recoil of the arterial wall, which becomes fainter the more distant the vessels are from the heart. When the capillaries are reached it is a continuous or a steady flow of blood, without any recoil of the arterial wall, which passes into the veins. Thus the elasticity of the arteries is for the purpose of equalizing the movement of the blood throughout the arterial system.

Contractility.—Contractility of the arteries is dependent upon the muscular tissue in their walls. They are supplied by nerve filaments which receive impulses from the controlling centres in the spinal cord, which communicate by means of ganglia with the sympathetic system, and the latter distributes filaments to the middle or muscular coat of the arteries. The centres in the spinal cord are called the **vasomotor centres**, and the nerve filaments the **vasomotor nerves**. The centres in the spinal cord are influenced chiefly by a main centre situated in the medulla; in other words, the spinal centres are underlying centres of this system.

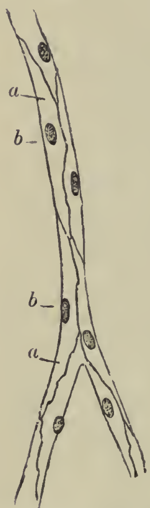
The vasomotor nerves possess two sets of fibers: those which when stimulated raise the blood pressure or contract the arterial wall—called vasoconstrictor nerves; and those which lower arterial pressure or dilate the arterial wall—called vasodilator nerves. These two sets of nerves, both when active although antagonistic to each other in function, tend to keep the arteries in a normal state of contraction, thus regulating the blood pressure and caliber of the arteries.

The **vasa vasorum** is the term defining the bloodvessels which supply the walls of the arteries. They are, of course, very minute bloodvessels which nourish them, and are derived from adjacent branches and have no direct opening into the channel of the artery they

supply. They are located in the tunica media or middle coat. The lining coat or intima of an artery is nourished by the column of blood passing over it.

The arteries give off branches which become smaller as their destination—the capillary area of the circulation—is reached. Just before emerging into capillaries, these small branches are termed **arterioles.**

Fig. 74



Capillaries from the mesentery of a guinea-pig after treatment with a solution of nitrate of silver: *a*, cells; *b*, their nuclei. (Gray.)

The Capillaries.—The capillaries consist of a series of minute blood-vessels which divide and subdivide to form interlacing net-works. The walls of a capillary consist of a single layer of flattened endothelial cells, nucleated, and held together by a cement substance. These thin-walled vessels possess irritability, contractility, and tonicity. They freely communicate with one another, and are the connecting link for the passage of the blood from the arteries to the veins. They are just large enough to transmit a small red cell.

The functions of the capillary wall is to allow an exchange of the nutritive elements of the blood with the tissues, and to receive from the tissue the waste products arising as a result of metabolism, taking place in the protoplasm of the tissue cells. This interchange between the blood and the tissues is due to the thinness of the capillary wall, aided by the phenomena of diffusion, osmosis, and infiltration (see Absorption, page 286).

The Veins.—The veins consist of three coats: the tunica intima, media, and adventitia. They differ from the arteries by their middle coat possessing less elastic and muscular tissue, but an increase in the

amount of fibrous connective tissue. They readily collapse when empty, do not pulsate, and possess elasticity and contractility, but not as marked as seen in the arteries; however, these properties aid in forcing the column of blood toward the heart, after leaving the capillaries—particularly after any obstruction to the flow of the blood stream. The veins collect the blood from the capillary area throughout the body, and return it to the right side of the heart. They start as very small vessels—called **venules,** and then become veins, which increase in size as they course toward their main trunks.

Veins possess **valves,** arranged in pairs, composed of folds of the lining membrane intima. They always project toward the heart, and are flattened against the wall of the vessel if the blood is flowing unobstructed toward the heart; but when any obstruction takes place they are distended into the channel, preventing a return flow, or regurgitation of the blood.

The veins distend under these conditions—due to their elasticity and accommodate the blood, until the obstruction is removed, when the muscle fibers in the wall contract and force the column of blood onward. With the congestion relieved, the valves again collapse against their walls.

The Pulse.—The pulse is the regular beat which is transmitted to the examining finger when placed on an artery. It is felt best in the radial artery by making gentle pressure with the tip of the index finger in the region of the artery at the lower fourth of the forearm on the outer side—when the palm is turned upward or supinated, just a little above and to the inner side of the prominence of the styloid process of the radius. By pressing downward the beat or pulsation can be felt. The artery lies on a firm bed formed by the flexor longus pollicis, and pronator quadratus muscles, beneath which is the bone. The expansion of the artery is due to the

response of the arterial system—which is receiving at every systole or contraction of the ventricle—a large volume of blood; the shrinkage of the artery is due to the elastic recoil of the arterial system or their walls upon the volume of blood, forcing it forward, into, and through the arteries, during the diastole or relaxation of the ventricles. The pulse or pulse wave is simply a wave passing from the heart over the arterial system, forcing the blood throughout the body until the capillaries are finally reached, when the column of blood passes into the venous system.

The **number of beats of the pulse is** 72 per minute, and varies accordingly. (See Heart-beat, page 183.) The pulse is influenced by the same factors which interfere with the heart's action. The pulse is spoken of as frequent or infrequent, depending whether it is above or below the normal rate—72 per minute; quick or slow according to the suddenness with which it strikes the examining finger; hard or soft, tense or easily compressible, depending on the resistance which the artery offers to the compressing finger; large, full, or small, depending on the amount of blood in the arterial system at the time of examination.

The Blood-pressure.—The blood-pressure or **arterial** tension may be defined as the pressure exerted radially or laterally by the moving blood-stream against the sides of the vessels (Brubaker).

The blood-pressure is greatest in the aorta and gradually lessens as the blood is forced through the vessels and emerges into the arterioles and capillaries, then passes through the venules into the veins.

At each contraction of the heart a large volume of blood is thrown into the arterial system, which is already engorged. This mass of blood in the arterioles and capillaries must be forced along to accommodate the next column of blood thrown from the ventricle, to relieve the arterial system of its already overdistended condition, and maintains an even distribution

of blood through the vascular system. Owing to the small caliber of the arterioles the blood meets with considerable resistance in passing through the arterioles. As a result, there is a marked decrease in the pressure in the arterioles and capillaries, due to this great resistance, which is called the **peripheral resistance.** The latter is caused by the small diameter of the vessels modified by the tonic contraction of the muscles in the wall of the arterioles.

A practical idea of the blood-pressure can be obtained from observing a cut or injured bloodvessel. If a large artery, the blood will be seen to project from the cut end nearest the heart, as a bright red fluid spurting from the vessel, with considerable force, dependent on the degree of pressure which it had been subjected to in the vessel, and the tension of the vessel wall before the injury. A vein when injured bleeds with no spurting or force. It is seen as a dark blue fluid coming from the cut end away from the heart, as a steady stream (welling up). These differences in the characters of the hemorrhage from an arterial and venous course indicate the difference of blood-pressure between the arterial and venous systems.

The **venous pressure** continues to fall from the capillaries to the heart. There is simply a steady tone to the walls of the veins which propel the blood to the right side of the heart without any pulsation.

The **capillary pressure** is dependent on the blood-pressure of the arterioles and venous systems. It is too minute to observe under normal physiological conditions.

THE DESCRIPTION OF THE ARTERIES, THEIR DISTRIBUTION, ETC.

There are two great arterial systems: (1) The pulmonary, to the lungs; (2) the corporeal, to every other part of the body.

The Pulmonary Arterial System.—The **pulmonary artery** is a short, wide vessel, 2 inches in length. Commencing at the base of the right ventricle, it curves upward and backward, to end under the transverse aorta by dividing into a right and a left branch, which convey the blood from the right auricle to the lungs.

This vessel, with the ascending aorta, is enclosed in a sheath of pericardium. It winds around the aorta, being at first in front, and later to the left side, of the ascending portion. In fetal life the ductus arteriosus connects it a little to the left of its division with the transverse aorta.

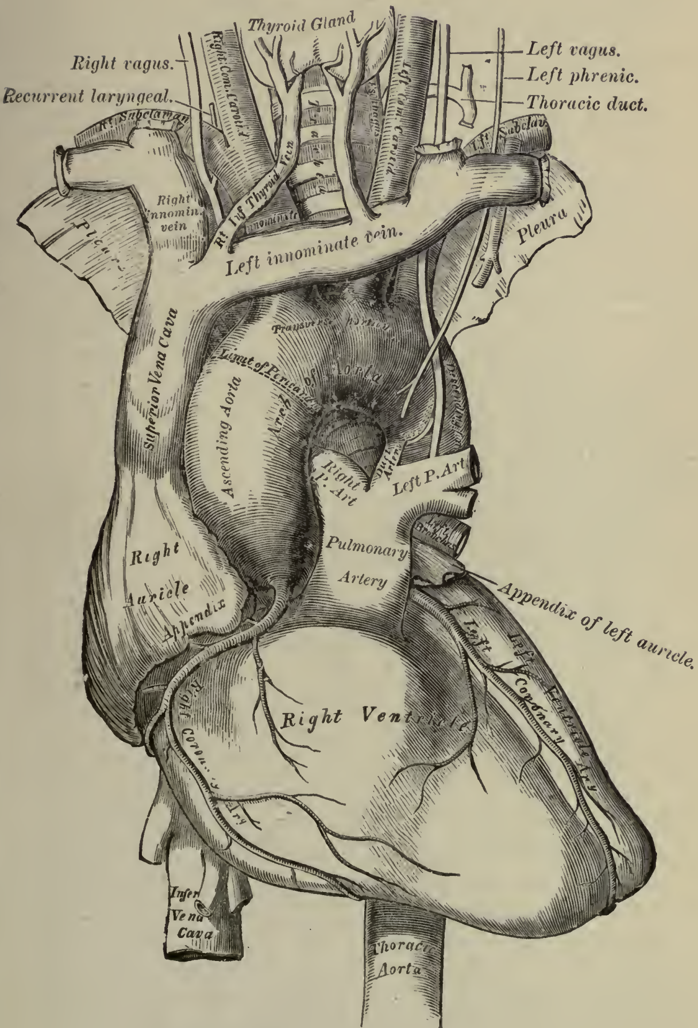
Each branch enters the hilum of the corresponding lung; the right, the larger, passing behind the ascending aorta and superior vena cava; the left, in front of the descending aorta. The left divides into two branches for the lobes of the left lung; the right also divides into two primary branches for the upper and lower lobes. From the lower one of these is sent a branch to the middle lobe. The pulmonary arteries are the only arteries which carry venous blood.

The Corporeal Arterial System. — The Aorta.— The aorta is the main trunk from which spring the systemic arteries. From the base of the left ventricle it runs upward, forward, and to the right as far as the second right cartilage; then backward and to the left, over the root of the left lung, to the fourth dorsal vertebra; thence, along the spine, it descends through the thorax and abdomen, to divide at the fourth lumbar, into the common iliacs.

It has been divided, for convenience of description, into the arch and the descending aorta. The arch is subdivided into the ascending, transverse, and descending parts; the descending aorta, into the thoracic and abdominal portions.

The Arch of the Aorta. The **ascending part of the arch** runs upward, forward, and to the right, from a point opposite the lower border of the third left

Fig. 75



The arch of the aorta and its branches. (Gray.)

cartilage, to the upper border of the second right cartilage. Close to its origin it presents three small dilatations, the sinuses of Valsalva, indicating the situation of the semilunar valves.

The **transverse part of the arch** passes backward and to the left as far as the left side of the body of the fourth dorsal vertebra.

The **descending part of the arch** descends to the lower border of the fifth dorsal vertebra, ending in the thoracic aorta.

The Branches of the Arch of the Aorta.—The **branches of the arch** are five—coronary, right and left, from the ascending part; and the innominate, left carotid, and left subclavian, from the transverse part. The descending part gives off no branches.

The **coronary arteries** supply the heart and the coats of the great vessels.

The **innominate (brachiocephalic) artery** is the largest branch. It arises in front of the left carotid, and runs obliquely to the right sternoclavicular joint, where it divides into the right common carotid and right subclavian.

The **common carotid arteries** are identical in course, branches, and relations in the neck, but differ in their origin. Thus, the right is a branch of bifurcation of the innominate, while the left is a primary branch of the transverse aorta.

The **external carotid artery** runs from the bifurcation of the common carotid to the space between the neck of the condyle of the mandible and the auditory meatus, and there divides into the superficial temporal and internal maxillary.

The **internal carotid artery** is a very tortuous vessel, and at its origin is farther from the median line than the external carotid, deriving the name "internal" from its distribution. For description it is divided into four parts: the first, or cervical; the second, or petrous, is in the carotid canal; the third, or cavernous

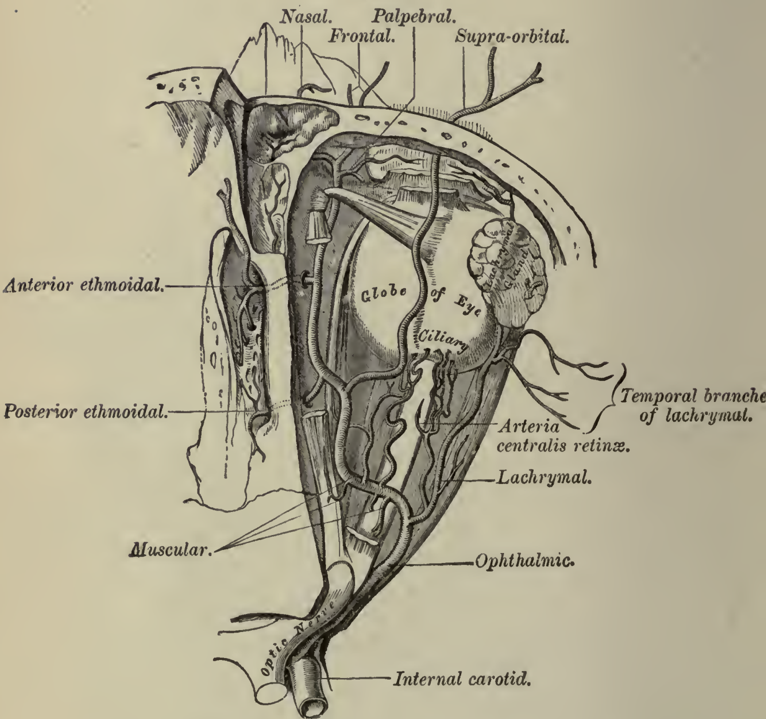
runs in the cavernous sinus; and the fourth, or cerebral, is the terminal portion, and supplies a portion of the brain and eye-ball.

FIG. 76

Applied anatomy of the arteries of the neck, showing the carotid and subclavian arteries. The hypoglossal nerve is not rightly placed in this drawing. It forms the upper side of a triangle, the two lower sides of which are the two bellies of the digastric. The lingual artery would then run under the hyoglossus muscle, below the hypoglossal nerve. (Gray.)

The **subclavian arteries** are divided into three parts, the first running to the inner margin of the scalenus anticus; the second, behind that muscle; the third, from its outer border to the lower border of the first

FIG. 77



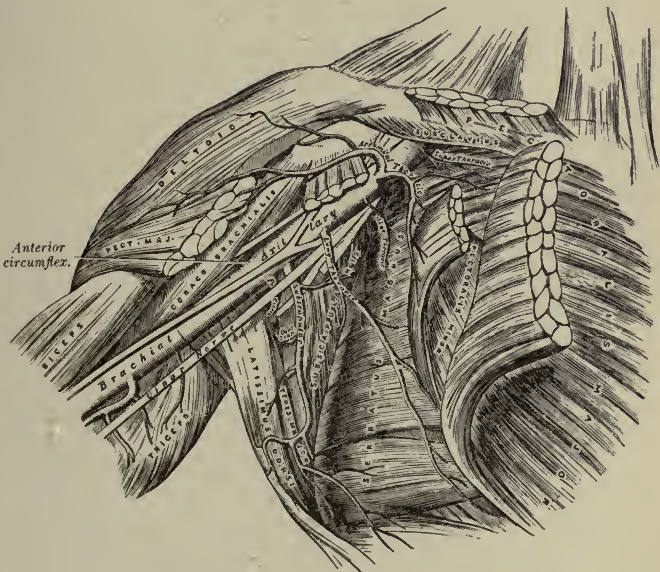
The ophthalmic artery and its branches, the roof of the orbit having been removed. (Gray.)

rib, where it becomes the axillary artery. The right and left vessels differ only in their first portions, the right arising behind the sternoclavicular joint, from the innominate; the left, from the transverse aorta as a primary branch.

The **basilar artery**, formed by the two vertebrals, runs to the upper border of the pons, and divides into the two posterior cerebrals. It gives off the following branches:

(*a*) Several *transverse arteries* on each side. One the auditory, enters the internal meatus; another, the *anteroinferior cerebellar*, to the anterior border of the cerebellum.

FIG. 78



The axillary artery and its branches. (Gray.)

(*b*) The *superior cerebellar*, to the upper surface, joining the inferior cerebellar.

(*c*) The *posterior cerebrals*, to the under surface of the posterior lobes of the cerebrum, receiving the *posterior communicating*. They give off the *posterior choroid* branches and supply the posterior perforated space.

The **circle of Willis** is situated at the base of the brain, it is an anastomosis formed by the bloodvessels of the brain. The arteries entering into its formation are: In front, the two anterior cerebral arteries, branches of the internal carotid, which are connected by the anterior communicating artery; behind, by two posterior cerebral arteries, branches of the basilar, and these communicate latterly with the internal carotids through the posterior communicating arteries.

The Arteries of the Upper Extermity.—THE AXILLARY ARTERY. The **axillary artery** is the continuation of the subclavian. It extends from the lower border of the first rib, where it is deeply placed, to the lower border of the teres major tendon, where it is superficial, and there becomes the brachial. It is described in three parts—the first, above the pectoralis minor; the second, behind it; and the third, below it.

Branches.—First part, superior and acromial thoracic; second part, long and alar thoracic; third part, subscapular and circumflex, posterior and anterior.

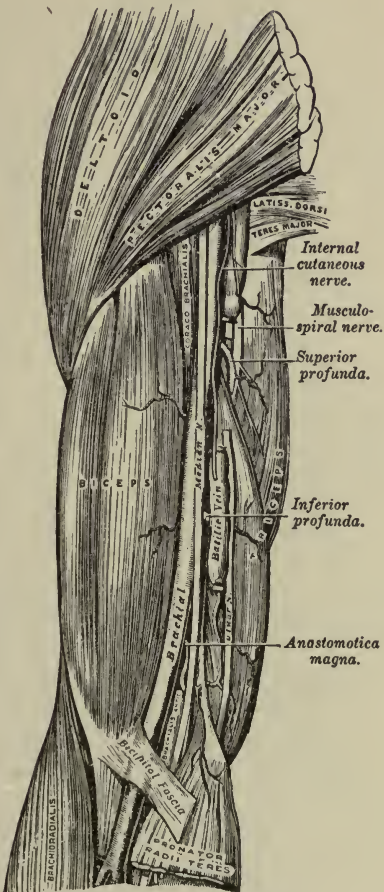
THE BRACHIAL ARTERY.—The **brachial artery** extends from the end of the axillary, at the lower border of the teres major, to $\frac{1}{2}$ inch below the elbow-joint, dividing into the radial and ulnar arteries.

The branches of the brachial artery are: The superior profunda, nutrient artery, to the humerus, the inferior profunda, anastomotica magna, and muscular..

THE RADIAL ARTERY.—The **radial artery** runs from the bifurcation of the brachial along the radial side of the forearm to the wrist, and winds back to its posterior surface. It then enters the palm through the first dorsal interosseous, and runs across the hand to form the **deep palmar arch** by joining the deep branch of the ulnar, and gives off in the ball of the thumb the superficialis volæ, a branch which joins with the main termination of the ulnar artery to form the **superficial palmar arch.**

The Ulnar Artery runs along the inner side of the forearm to the wrist, crosses the annular ligament

Fig. 79



The brachial artery. (Gray.)

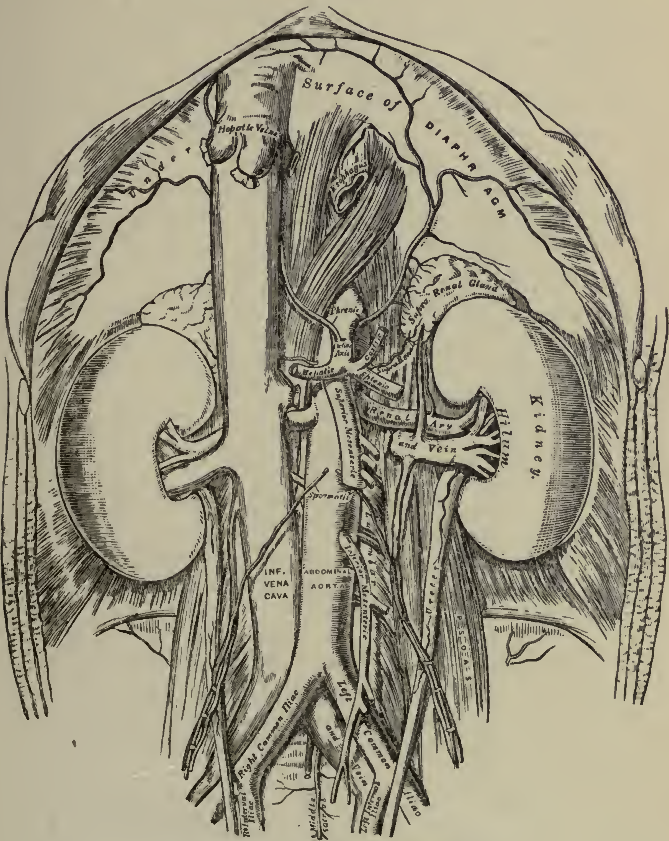
and the palm of the hand, and joins the superficialis volæ to form the superficial arch.

Fig. 80

The radial and ulnar arteries (Gray.)

The **superficial palmar arch** lies beneath the palmar fascia and above the flexor tendons of the fingers.

Fig. 81

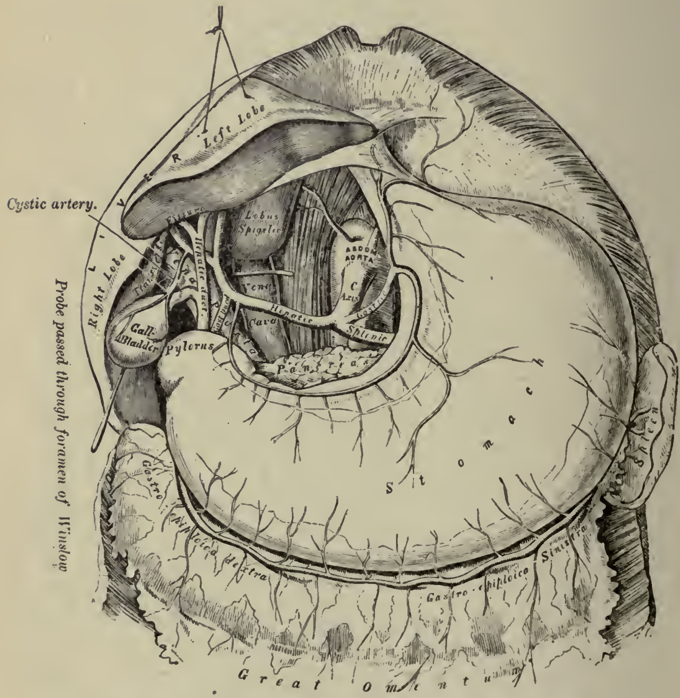


The abdominal aorta and its branches (Gray.)

The **deep palmar arch** lies beneath the flexor tendons and rests on the metacarpal bones and palmar interosseous muscles.

The Thoracic Aorta.—The **thoracic aorta** descends from the lower border of the fifth to the front of the last dorsal vertebra.

FIG. 82



The celiac axis and its branches, the liver having been raised and the lesser omentum removed.

The Abdominal Aorta.—The abdominal aorta runs from the last dorsal to the left side of the middle of the fourth lumbar vertebra, there dividing into the two common iliacs.

The **branches of the thoracic aorta:**

Nine pairs of intercostal arteries, two subcostal, bronchial, esophageal, mediastinal, and pericardial.

The **branches of the abdominal aorta:**

(*a*) Parietal and (*b*) visceral.

The Parietal Branches.—(1) The **phrenic,** (2) the **lumbar,** (3) the **middle sacral.**

The Visceral Branches.—I. The **celiac axis,** $\frac{1}{2}$ inch long, divides into the *gastric, hepatic,* and *splenic.* It is covered by the lesser omentum, rests below on the pancreas; on each side is a semilunar ganglion and on the right the lobus Spigelii, of the liver on the left the stomach.

Branches.—(*a*) The *gastric* artery runs to the cardiac orifice of the stomach, thence to the right, along the lesser curvature, in the lesser omentum as far as the pylorus. It supplies both surfaces of the stomach and the esophagus, anastomosing with the splenic, hepatic, and esophageal arteries.

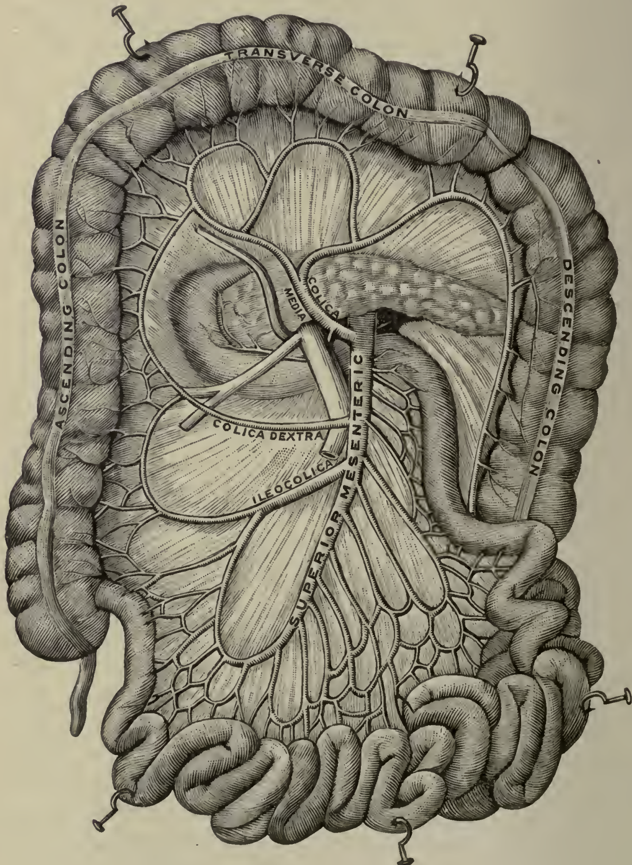
(*b*) The *hepatic* artery passes below the foramen of Winslow to the pylorus, then ascends in the lesser omentum, anterior to that foramen, and to the left of the gall duct, to the transverse fissure of the liver, and divides into a *right* and a *left* branch. Its *pyloric* branch passes along the lesser curvature to meet the gastric. Its *cystic* branch from the right division ascends on the neck of the gall-bladder and supplies it by two branches. The other branch of the hepatic, the *gastroduodenalis,* divides behind the lower part of the duodenum into a *superior pancreaticoduodenal* branch, descending between the pancreas and duodenum to join the inferior artery of the same name; and the right *gastro-epiploica,* passing into the omentum toward the left, along the great curvature, to meet the left. (See Fig. 82.)

(*c*) The *splenic* runs tortuously to the left, along the upper border of the pancreas, and divides near the spleen into branches which enter at the hilum, some passing to the stomach.

Branches.—*Pancreatic,* numerous, small; and one larger, the *pancreatica magna,* accompanies the duct of Wirsung.

Five to seven *vasa brevia*, in the gastrosplenic omentum, to great end of the stomach, joining the gastric and gastro-epiploic vessels. (See Fig. 82, page 202.)

Fig. 83



Superior mesenteric artery. (Testut.)

The left *gastro-epiploica* runs to the right, along the great curvature, to join the right.

II. The **superior mesenteric** supplies the small intestine except the first part of the duodenum, as well as the cecum, appendix, ileum, and ascending and transverse colon. Emerging from between the transverse duodenum and pancreas, it crosses the former, and descends in the mesentery to the right iliac fossa with its veins and a plexus of nerves. It ends by anastomosing with its own ileocolic branch. (See Fig. 83.)

III. The **inferior mesenteric** supplies the descending colon, sigmoid flexure, and upper part of the rectum, and its continuation. (See Fig. 83.)

IV. The **suprarenals,** to the under surface of the suprarenal capsules, join branches of the phrenic and renal arteries.

V. The **renal**, to the hilum of the kidney, enters by four or five branches, into which each vessel divides close to the kidney.

VI. The **spermatic**, the **ovarian** in the female, to the testicles or ovaries respectively.

The Iliac Arteries.—The common iliac arteries run downward and outward from the division of the aorta to the lumbosacral joint, and divide into the external and internal iliacs. (See Fig. 81, page 201.)

The **internal iliac artery** descends to the upper part of the great sacrosciatic foramen, and divides into an anterior and a posterior trunk.

The *posterior trunk* gives off the following *branches:* (*a*) the **iliolumbar**; (*b*) the **lateral sacral**; (*c*) the **gluteal,** passes through the great sciatic foramen, and divide into a superficial and a deep branch.

The *anterior trunk* of the internal iliac gives off the following *branches:*

(*a*) The **superior vesical** represents the pervious part of the fetal hypogastric artery. It runs to the apex and body of the bladder and to the ureter, joins its fellow, and gives off the *artery* of the *vas deferens,* which accompanies that structure to the testicle. It

also generally gives off the (*b*) middle vesical to the base of the bladder.

(*c*) The **inferior vesical—vaginal** in the female—joins its fellow. It supplies the bladder, prostate gland, and seminal vesicles; in the female, vagina, and rectum.

(*d*) The **middle hemorrhoidal** arises with the preceding, and runs to the rectum to join other hemorrhoidal arteries.

(*e*) The **uterine** in the female ascends in the broad ligament from the cervix along the side of the uterus, and joins the ovarian artery.

(*f*) The **obturator** runs forward below the pelvic brim, between the peritoneum and pelvic fascia below the nerve, then through the upper part of the obturator foramen, dividing beneath the obturator externus into an *external* and an *internal* branch.

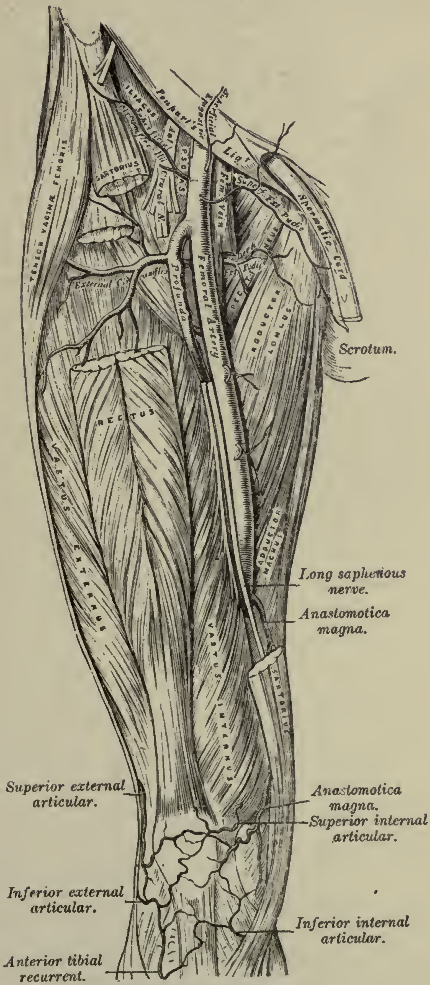
The termination of the anterior trunk of the internal iliac then divides into two branches, the sciatic and the internal pudic arteries.

The **external iliac artery** extends from the division of the common iliac to the midpoint between the symphysis of the pubis and the anterior superior spine of the ilium, behind Poupart's ligament.

The Arteries of the Lower Extremity.—The Femoral Artery.—The **femoral artery** continues the external iliac artery down into the thigh to end at the opening in the adductor magnus at the junction of the upper three-fourths and lower one-fourth of the femur. From its beginning to the point where the profunda femoris is given off, it is called the common femoral, below this the superficial femoral. Its upper part lies in *Scarpa's triangle,* bounded above by Poupart's ligament, the inner side formed by the inner margin of the adductor longus, the outer by the sartorius. Its floor, from without inward, is made up of the iliacus, psoas, pectineus, and adductor brevis. The lower part runs in Hunter's canal, a depression between

the vastus internus and the adductores magnus and longus, covered by a strong fascia passing between them.

FIG. 84



The femoral artery. (Gray.)

The Popliteal Artery.—The popliteal artery runs from the adductor opening to the lower border of the popliteus, passing through the popliteal space at the back of the knee-joint, where it divides into the anterior and posterior tibial.

The **anterior tibial artery** runs from the lower border of the popliteus, between the heads of the tibialis posticus and above the interosseous membrane, to the front of the leg, then descends as far as the ankle, ending in the *dorsalis pedis.*

The **dorsalis pedis** is the continuation of the anterior tibial, and runs from the bend of the ankle to the first interosseous space, where it divides into the *dorsalis hallucis* and *plantar digital.*

The **plantar digital** branch of the dorsalis pedis artery passes between the heads of the first dorsal interosseous, joins with the external plantar to form the plantar arch, and after supplying the inner side of the great toe, divides into two branches for the adjacent sides of the great and second toes.

The **posterior tibial artery** runs from the lower border of the popliteus to divide, between the inner malleolus and heel, into the *external* and *internal plantar* arteries.

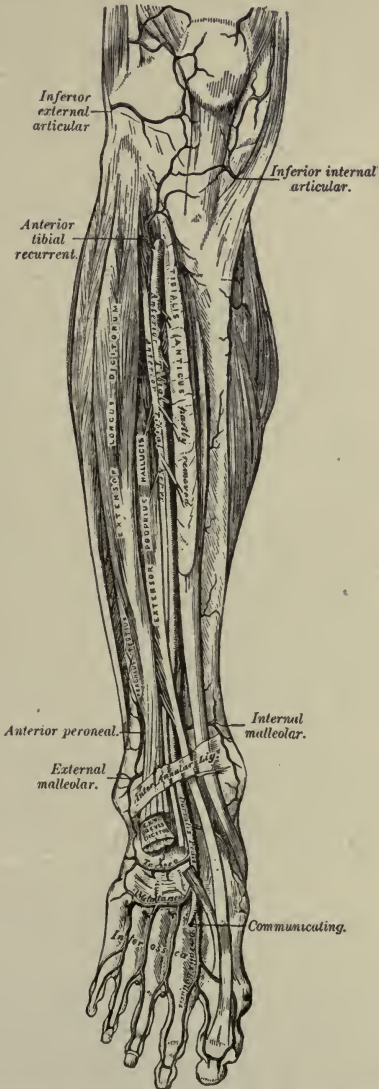
The **plantar arteries** are the terminal branches of the posterior tibial. The **internal** is at first under cover of the abductor pollicis, and then between it and the flexor brevis digitorum, anastomosing at the inner border of the great toe with its digital artery.

The **external**, the larger, passes to the base of the fifth metatarsal, then to the space between the first and second metatarsals, and joins the plantar digital, from the dorsalis pedis, to form the plantar arch.

The **plantar arch** supplies the muscles, fascia, and skin of the sole of the foot, and gives off the *posterior perforating.* These pierce the three outer spaces between the heads of the dorsal interossei and join the dorsal interosseous arteries.

The *digital,* four in number, supply the three outer

FIG. 85



Applied anatomy of the anterior tibial and dorsalis pedis arteries. (Gray.)

toes and the outer half of the second toe; the first runs to the outer side of the little toe, the others bifurcate to the adjacent sides of the fourth and fifth, fourth and third, third and second toes. At the point of bifurcation each sends a small branch to join the dorsal interosseous arteries (*anterior perforating*).

Fig. 86

The plantar arteries. Deep view. (Gray.)

DESCRIPTION OF THE VEINS

The Systemic Veins.—These are divided into three sets: **superficial, deep, and sinuses.**

The **superficial veins** are usually found between the layers of the fasciæ just beneath the skin.

The **deep veins** accompany the arteries, as a rule, and are usually found in the same sheath, derived from the deep fascia. They are generally in pairs, one on each side of the artery, and are termed **venæ comites.** The larger arteries have only one accompanying vein—as the axillary, subclavian, popliteal, femoral.

Sinuses are venous channels found in the skull, which drain the blood from the brain and its membranes, and ultimately communicate with the right and left internal jugular veins at the base of the skull. Some are found between two layers of the dura, and others lodged in grooves on the inner surfaces of the cranial bones, ensheathed by the dura. They are lined by endothelial cells continuous with that which lines the veins. They are sixteen in number—six single and ten paired.

Venous plexus is the name given to a number of small veins communicating with each other and arranged in a net-work surrounding or within any organ or part of the body.

The Veins of the Heart.—The **great cardiac** vein ascends in the anterior interventricular groove from the apex of the heart to the left auriculoventricular groove; along this latter it runs to the posterior surface of the heart, to end in the coronary sinus. At its termination it is provided with a valve.

The **right (small) coronary** vein in the right auriculoventricular groove to the sinus.

The **coronary sinus,** one inch long, is placed at the back part of the auriculoventricular groove, on the left side, and opens into the right auricle in front of the inferior vena cava.

The Superior Vena Cava and Innominate Veins.—The **superior vena cava** is a large trunk formed by the union of the two venæ innominatæ, and returns the

blood from the head and neck, the thoracic walls, and the upper extremities. It is about three inches long, and descends from the junction of the first right costal cartilage with the sternum to its termination in the right auricle, opposite the upper border of the third right cartilage.

The Veins of the Head and Neck.—The **facial vein** runs from the inner angle of the eye to the anterior border of the masseter muscle, then backward below the jaw, joining the anterior division of the temporomaxillary trunk to form the common facial, which joins the internal jugular.

The **temporomaxillary vein** (**posterior facial**) is a short trunk, formed by the *temporal* and *internal maxillary* veins.

The **temporal vein** is formed by the union of the *superficial* with the *middle temporal* vein, and crosses over the zygoma and under the parotid to join the internal maxillary vein.

The **external jugular vein** is formed by the union of the posterior auricular and the posterior division of the temporomaxillary trunk. It descends obliquely across the sternomastoid, lying between the platysma and fascia. Above the clavicle it pierces the fascia and joins the subclavian at the outer border of the scalenus anticus; sometimes it joins the internal jugular.

The **internal jugular vein** commences at the jugular foramen just below the junction of the inferior petrosal with the lateral sinus, and descends with the external carotid, then with the common carotid, to join at a right angle with the subclavian vein behind the clavicle, thus forming the innominate vein. It is placed external to the carotid vessels, lying in the same sheath with each in turn.

The Veins of the Upper Extremity.—The Superficial Veins.—They commence from a plexus on the back

of the hand mostly, but to some extent from the palm. They comprise the following:

The **ulnar,** *anterior* and *posterior,* uniting above in the common ulnar.

The **radial** vein is situated on the outer side, and the *median* ascends mesially, receives a *deep median* vein, and divides at the bend of the elbow into the median basilic and median cephalic.

The **median basilic** joins the common ulnar to form the basilic. The bicipital fascia separates it from the brachial artery.

The *median cephalic* crosses the external cutaneous nerve, and joins the radial to form the cephalic.

The **basilic** runs along the inner side of the biceps, pierces the fascia, and is continued upward into the axillary vein.

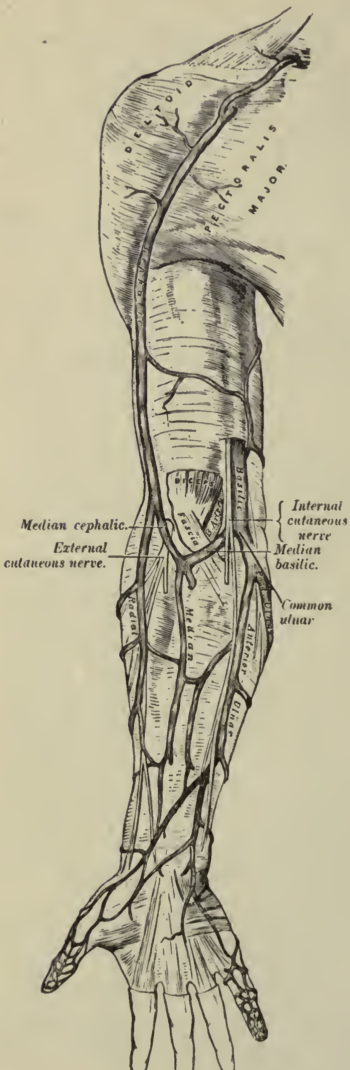
The **cephalic** runs along the outer side of the biceps, and between the pectoralis major and deltoid, piercing the costocoracoid membrane to join the axillary vein below the clavicle.

The Deep Veins.—The **axillary** vein begins where the venæ comites of the brachial artery and the basilic vein unite. It runs internal to the artery, and receives veins corresponding to its branches, as well as the cephalic.

The **subclavian** vein is the continuation upward of the axillary, and runs at a lower level than its artery, from which it is separated by the phrenic nerve and scalenus anticus, to the inner border of that muscle, to join the internal jugular, forming the innominate. It receives the *external jugular*, and occasionally the *anterior*.

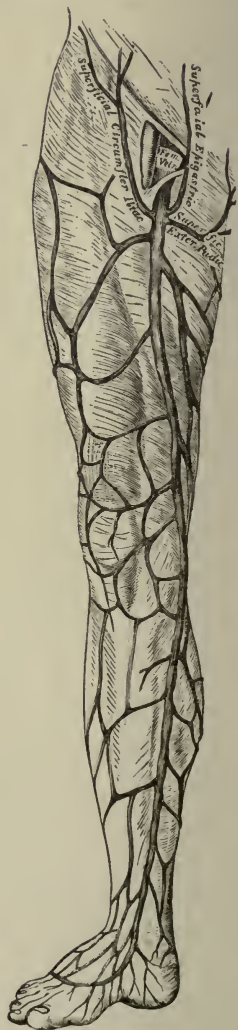
The Inferior Vena Cava.—This large trunk arises at the fifth lumbar by the union of the two common iliacs. It ascends to the right of the aorta, grooves the posterior border of the liver, pierces the diaphragm, is enclosed by the serous layer of the pericardium, and empties into the right auricle.

Fig. 87



The superficial veins of the flexor aspect of the upper extremity.

Fig. 88



The internal or long saphenous vein and its tributaries. (Gray.)

The Veins of the Lower Extremity.—THE SUPERFICIAL VEINS.—They begin on the back of the foot in a plexus which receives the digital veins, and forms an arch from which emerge the internal or long and the external or short saphenous veins.

The **long (internal) saphenous**, from the inner part of the plexus, runs in front of the inner malleolus of the tibia, along with the long saphenous nerve, behind the inner border of the tibia and condyle of the femur; thence up along the antero-internal part of the thigh to join the femoral vein at the saphenous opening.

The **short (external) saphenous** vein ascends behind the outer malleolus, and external to the tendo Achillis, with the external saphenous nerve, and pierces the deep fascia in the popliteal space to join the popliteal vein.

THE DEEP VEINS.—These are the *venæ comites* of the arteries. The **posterior tibial veins** receive the **peroneal**, and join the **anterior tibial** to form the **popliteal.** This vessel then ascends, crossing superficial to the artery, from the inner to the outer side, and becomes the femoral at the opening in the lower border of the adductor magnus muscle. It receives the *external saphenous* and veins corresponding to the arterial branches.

The **femoral vein** accompanies the artery, and becomes the external iliac at Poupart's ligament. It is at first outside, then behind, and at its termination internal to, the artery as it lies in Hunter's canal. It receives, in its lower part, veins corresponding to the branches of the superficial femoral artery; the *long saphenous*, and the *profunda* vein.

The **external iliac** joins the internal iliac near the lumbosacral articulation, being at first internal to, later behind, the artery, and they empty into the common iliac vein on either side, the latter forming the inferior vena cava.

The Portal System.—The **portal vein,** three inches long, arises from the union of the splenic and superior

mesenteric veins behind the head of the pancreas, and ascends behind the duodenum and between the layers of the lesser omentum. Here it runs behind the hepatic artery and bile duct. Accompanied by the hepatic plexus of nerves and lymphatics, all enclosed in Glisson's capsule, it then enters the transverse fissure, forming near the right end the "sinus," and divides into: A *right* branch, to the right lobe, which distributes branches entering the hepatic substance with the hepatic arterial branches and ducts; and a *left* branch, distributed like the right. The portal vein also drains the pyloric, cystic, gastric, and parumbilical veins. The portal vein and its tributaries convey blood to the liver from the following organs —spleen, pancreas, stomach, gall-bladder, umbilicus, duodenum, small and large intestines, appendix, and upper portion of the rectum.

The vena portæ receives the following *tributaries:*

The **superior mesenteric** corresponding to the artery of the same name, receiving also the *right gastro-epiploic vein,* besides branches accompanying those of the artery. It joins the splenic vein.

The **splenic** arises by five or six vessels uniting after leaving the hilum, and runs to the right below the artery, joining the above at a right angle to form the vena portæ. It receives the *vasa brevia, left gastro-epiploic,* and *pancreatic branches,* and the inferior mesenteric vein.

The **inferior mesenteric** vein corresponds in branches and course to the artery, and empties into the angle of junction of the two preceding.

The **pyloric** runs with the pyloric branch of the hepatic artery, and joins the vena portæ; also the gastric vein which accompanies the gastric artery and receives the esophageal branches, joins the vena portæ above the former.[1]

[1] See Chapter on Absorption, page 287, for description of the function of the portal system.

BLOOD

The blood is contained in the bloodvessels, which are practically a closed arrangement of tubes—the arteries, veins, and their connecting capillaries.

Function.—The function of the blood is to transmit the various nutritive elements, absorbed from the organs of digestion to the tissues of the body, to carry to the tissues oxygen absorbed from the air in the lungs; to remove from the tissues the various waste products, such as urea, uric acid, water through the kidneys and skin, carbon dioxide (CO_2)—the latter being carried to the lungs by the red cells which give it off with the expired air; to maintain the temperature of the body in warm-blooded animals.

Physical Characteristics.—Blood is alkaline in reaction, opaque in color, and appears as a homogeneous mass. Two kinds of blood are contained in the vascular system—in the arteries it is bright red in color, while in the veins it is dark bluish in color. The color of the blood is due to the coloring matter—hemoglobin—contained in the red cells. The bright red color of normal blood is due to the hemoglobin in combination with the oxygen, which it absorbs on coming in contact with the air in the lungs. The bluish color of venous blood is due to the hemoglobin absorbing the carbon dioxide from the tissues—a waste compound which is being carried to the lungs to be given off in the expired air.

Constituents of Blood.—It consists of a liquid portion called the **liquor sanguinis** or **plasma, red cells** or **erythrocytes, white cells** or **leukocytes,** and **blood plaques.** (Of course the latter can only be seen with the microscope.)

The Plasma.—This is a clear, slightly yellowish, transparent fluid, consisting mostly of the nutritive elements of the foods—proteins, carbohydrates, fats, inorganic salts—which have been rendered possible

of absorption by the process of digestion; and waste products (urea, cholesterin, etc., resulting from the breaking down of tissues following their functional activities), which are carried to the kidneys, lungs, and skin to be eliminated.

Serum.—Serum is a clear, transparent, straw-colored fluid formed when blood coagulates or clots, due to the contraction of the fibrin which separates after several hours, following withdrawal or is found by whipping the blood with twigs, upon which the fibrin forms as whitish threads. The serum consists practically of the same substances as the plasma, excepting the proteins which are found in the fibrin.

Serum-albumin represents the protein constituents of the blood found in the plasma. It is absorbed from the digestive tract in the form of peptones which are formed from the proteins in a manner not definitely decided upon by physiologists. It replaces the proteins which have been used up in the disintegration of tissues (anabolism).

Paraglobulin is supposed to be similar to serum-albumin as regards its function, and can only be isolated from the blood serum by chemical methods.

Fibrinogen is found in the blood, plasma, lymph, pericardial, and peritoneal fluids. It can only be studied by treating blood by chemical means before coagulation. Its importance in regard to its function and nutritive values is an undetermined quantity, aside from the fact that it contributes to the formation of fibrin.

Fat is found in the serum as microscopic globules. The amount is very small (0.25 per cent.); however, after a hearty meal the quantity is increased.

Sugar is present in the form of dextrose, which is a member of the carbohydrate group of body constituents derived from fruits, cereals, etc., taken as foods.

Extractives include the nitrogenized bodies, urea, uric acid, creatin, xanthin, etc., various chemical com-

binations and decompositions, which result from the breaking down of muscle and nerve tissues. They occur in very small amounts, being continually absorbed from the tissues by the blood, but seldom accumulate, as they are rapidly and continually passed off through the kidneys, bowels, skin, etc.

Inorganic Salts.—Sodium and potassium chlorides, phosphates and sulphates, calcium and magnesium phosphates are found in the plasma. Sodium chloride is the most important. The alkalinity of the blood is due to the contained salts, some of which are alkaline in reaction.

The Red Cells.—*Red cells, corpuscles,* or *erythrocytes* are seen after a drop of freshly drawn blood is examined under the microscope. They appear as disk-like cells, floating or swimming about in the blood plasma. After a few minutes they will be seen to group themselves in a number of columns of varying lengths, resembling rolls of coins. Also a few white cells will be seen floating about in the plasma.

A single cell is slightly yellow or greenish. Numbers when collected together appear red. The color is due to the presence within the cell of the coloring matter, hemoglobin. The diameter of a red cell is $\frac{1}{3200}$ of an inch or 0.0075 mm.; $\frac{1}{12800}$ or 0.0019 mm. in thickness. The average number of red cells in one cubic millimeter of blood is 5,000,000 for the male; 4,500,000 for the female.

Chemic Composition.—The corpuscle consists of hemoglobin, about 30 per cent. of total weight, the rest, 70 per cent., contains 68 per cent. water, 2 per cent. solid matter, *e. g.*, cholestrin, lecithin, and inorganic salts.

The **function** of the red cell is to carry oxygen to the tissues, where it enters into combination with them (oxidation). This phenomenon is made possible by the hemoglobin contained in the red corpuscle. When the red cells in the blood come in contact,

under the oxygen pressure, with the air we breathe into our lungs, the hemoglobin absorbs some of the oxygen, through a chemical union (oxyhemoglobin); immediately the blood becomes bright scarlet color on leaving the lungs; as the tissues are reached by this blood, when the oxygen pressure is low, the oxyhemoglobin gives up some of its oxygen to the tissues, and the blood becomes bluish in color (reduced blood); whereupon it returns through the veins to the lungs by way of the heart, to be oxidized again.

The White Cells.—The **white cells, corpuscles,** or **leukocytes** are composed chemically of 90 per cent. water, the balance solid matter, mostly proteins, *e. g.*, nuclein, nucleo-albumin, which contain phosphorus (as much as 10 per cent.), cell globulin, also lecithin, fat, glycogen, earthy and alkaline phosphates.

The **number** of white corpuscles is much less than the red corpuscles, thus in 1 cubic millimeter the ratio is about 1 white to 700 red. The average number of white cells in a cubic millimeter of blood is between 7500 to 8000. The number may be increased or reduced by the following physiologic conditions: Taking of food rich in proteins raises the number 30 to 40 per cent.; in the newborn, 17,000 to 20,000 per cubic millimeter; latter days of pregnancy they are as high as 15,000 to 20,000; they are increased in various pathologic conditions, such as abscess, peritonitis, appendicitis, pneumonia. Starvation reduces the number.

The white cells as seen under the microscope floating in the blood plasma, appear as grayish cells, about $\frac{1}{2500}$ inch in diameter, adhering to the walls of the vessel.

The cell structure appears as a homogeneous mass containing numerous granules consisting of fat, protein, and carbohydrate. A nuclei can be seen by the adding of a mild acid. They are ameboid, that is, they show movements similar to those seen in the

amebæ. As a result of this ameboid movement they assume a different shape from time to time. White cells have the properties of moving about and coming in contact with bacteria, and disintegrated tissues, then can be seen taking them into their substance and eliminating them from the cell or digesting the invader. They can by their movements slip through the wall of the capillary vessel and appear in the adjacent lymph spaces. This power of the white cell is best appreciated in the early stages of inflammation when the blood stream is always engorged with red and white corpuscles; the latter can be seen passing into, through, and outside the wall, and preparing to combat the invading germ causing the trouble. This action of the white corpuscles is called **diapedesis.**

The large and small lymphocytes originate in the lymph glands, the solitary and combined glands of the intestines, etc. They are carried into the blood stream from these glands by means of the flowing lymph. The polymorphonuclear, eosinophiles, basophiles, and leukocytes are derived from the bone-marrow only. They reach the circulation by entering the capillaries in the bone-marrow. Leukocytes disappear by a process of dissolution. The period of their life is unknown.

Function of White Cells.—The polymorphonuclear, large and small, lymphocytes possess the properties of engaging and removing bacteria and broken-down tissue. They attack and destroy more or less effectively forms of intruding bacteria by surrounding, and incorporating the tissue or bacterium and eliminating them by a process of digestion. This swallowing action of these white cells caused Professor Metchnikoff to call them **phagocytes**, and the process as **phagocytosis.** Thus these scavengers aid the human body in recovering from disease by combating and destroying the invading bacterium. White cells are supposed, after breaking up, to contribute certain protein

material to the blood plasma, which aids in the coagulation of blood.

Blood Plaques.—These are colorless disks consisting of protoplasm. Their diameter is 1.5 to 3.5 micromillimeters. The number compared to the red cells is 1 to 18 or 20. They are concerned mostly with the coagulation of the blood, by their adhering and forming irregular masses (Schultze), acting as a nucleus for the fibrin filaments to spread from during coagulation of the blood. They can only be seen microscopically after subjecting the blood to treatment with osmic acid.

Coagulation of Blood.—Blood when freshly drawn from a living body into a vessel is fluid. In a short time it becomes thickened or viscid, this increase in consistency becomes more marked until the vessel contains a dark reddish mass, resembling gelatin. Shortly a few drops of fluid appear on the surface of the mass, which gradually increases in amount, the vessel is seen to contain a deposit of a firm, organized mass —the clot—floating in a reddish-yellow fluid—the blood-serum. On examining a portion of the clot microscopically, it will show threads of fibrin with red and white corpuscles clinging to them.

The Clotting of Blood.—This is supposed to be a chemic phenomenon due to the action of a ferment, derived from calcium chloride, and some authors suggest leukocytes acting on the fibrinogen of the blood plasma, and converting it into fibrin and thus forming the nucleus of the clot. If blood is freshly drawn into a vessel, then whipped with a bundle of fine twigs for a few moments, the fibrin will be deposited on these twigs as whitish threads. Blood treated in this manner will not clot when left in the vessel; the serum will be the only residue present. This blood, treated as above, is called **defibrinated.**

QUESTIONS

1. Where is the pericardium found? Its function?
2. In which bony cavity of the body is the heart located?
3. What is the position of the heart in the thoracic cavity?
4. What relation does the apex bear to the chest wall?
5. Can the beat of the heart be felt at any point on the chest wall and where?
6 How many surfaces has the heart? Borders?
7. What are its dimensions? Weight, male and female?
8. What grooves can be seen on the external surface of the heart wall?
9. How many chambers has the heart?
10. What divides the right side from the left? The auricles from the ventricles?
11. How many auricles are there? Ventricles?
12. What name is given to the opening between the auricle and ventricle?
13 What is the lining membrane of the heart called?
14. What variety of cells are found in the endocardium?
15. What parts present themselves in the right auricle?
16. Name the small muscles found in the cavities of the right and left ventricles.
17. Name the valves found in the right and left auriculoventricular openings. The pulmonary artery and aorta.
18. How many leaflets has the mitral valve? Tricuspid valve?
19. What name is given to the cords extending between the papillary muscles and margins of the mitral and tricuspid valves?
20. Give a brief description of the course of the blood through the chambers of the heart?
21. What muscle transmits the contraction wave of the heart muscle from the right auricle to the ventricular walls?
22. How is the cardiac cycle divided?
23. How long does the cycle of the heart last? How divided?
24. Give the normal beat of the heart per minute in an adult. Fetus. First year of life. Third year. Eighth to fourteenth year.
25. At what point on the chest wall can the beat of the heart be heard best?
26. What causes the first sound of the heart? Second sound?
27. Describe briefly the fetal circulation.
28. Give the changes in the fetal circulation following birth.
29. Name the coats of an artery.
30. What variety of tissue renders arteries so elastic?
31. Why is the elasticity of the arterial wall so essential?
32. What causes arteries to contract?
33. What do you understand by the term vasa vasorum?
34. What are small arteries called? Veins?
35. What forms the walls of capillaries?
36. What are the functions of the capillaries?
37. How many coats form the wall of a vein?
38. Do some veins possess valves?

39. What is the pulse?
40. Where is the pulse usually counted best?
41. What is the pulse due to?
42. What do you understand by a frequent or infrequent pulse? Hard or soft? Tense or compressible? Large, full, or small?
43. Define blood pressure.
44. What do you understand by the term peripheral resistance?
45. How can you differentiate a hemorrhage from a vein or artery?
46. What causes the difference in character of an arterial from a venous hemorrhage?
47. What vessels carry the blood from the right ventricle of the heart to the lungs?
48. How does the blood leave the left ventricle of the heart?
49. How does the blood from the lungs reach the left auricle of the heart?
50. What large vein empties the systemic blood into the right auricle of the heart?
51. What are the divisions of the aorta.
52. Name the arteries supplying the following organs: stomach, kidney, liver, heart, lungs, uterus, large bowel, appendix.
53. Give the location of the superficial and deep palmar arches in the palm of the hand.
54. What are the branches of the transverse arch of the aorta?
55. What veins form the portal vein?
56. Name the organs which are drained by the portal vein and its tributaries.
57. What is the function of the blood?
58 Is blood alkaline or acid in reaction? What is the color of arterial blood? Venous blood?
59. What causes the red color of arterial blood? The bluish color of venous blood?
60. What are the constituents of blood?
61. What is the function of fibrinogen in blood?
62. Is sugar found in the blood? Fat?
63. What are the dimensions of a red cell?
64. Describe the appearance of blood under the microscope.
65. What is the function of the hemoglobin in the red cells?
66. What is the normal average number of red cells found in one cubic millimeter of blood in the male? Female?
67. What is the normal average number of white cells found in a cubic millimeter of blood?
68. What do you understand by the terms diapedesis, phagocytosis?
69. Describe the coagulation (clotting) of blood.
70. What are the functions of the white cells?

CHAPTER IX

THE LYMPHATIC SYSTEM

THE lymphatic system includes primarily the tissues or lymph spaces, the lymph and blood capillaries; secondarily, the lymphatic vessels, and lymph nodes or lymphatic glands, and the veins which subsequently receive the lymph through the large right and thoracic ducts.

The lymphatic system is supposed to be a closed system in relation with the tissues. The lymph reaches the lymphatic vessels by transudation through the endothelial lining of the vessels; this also occurs in the serous membranes, and is not due to the lymph passing by permanent openings between the cells (stomata), as was once held.

The Tissues or Lymph Spaces.—These are located in practically every tissue and organ of the body. They are found between cells (intercellular), around bloodvessels (perivascular), and around nerves (perineural); these spaces are not lined by endothelial cells; the cells are nourished as demonstrated above, by a transudation through the capillary walls, and the lymph comes in contact with the cells in the lymph spaces. The spaces in the cranial cavity, the subdural and subarachnoid, also the serous cavities, as the pericardial, pleural, peritoneal, and synovial bursæ, are lined by endothelial cells, and the lymph transudes or passes through the membranes by osmosis. The ventricles of the brain and the central canal of the spinal cord contain lymph from the blood capillaries of these parts, and communicate with the

subarachnoid space (see Coverings of Brain and Spinal Cord), whereupon it is taken up by the lymphatic vessels.

Lymph Capillaries.—These are the connecting vessels between the lymph spaces and the lymphatic vessels proper. They are thin-walled vessels, which consist of a single layer of endothelial cells. They are arranged in plexuses interwoven with the blood capillaries, and can be easily distinguished from them by their larger size and irregular expansions.

The **blood capillaries,** in relation with the lymph capillaries, permit of a transudation of the nutritive elements of the blood through their thin walls, and at the same time assist in the reabsorption of a portion of this transudate and waste products resulting from metabolism.

The Lymphatic Vessels.—They are arranged into a superficial and deep set. The **superficial set** pass just beneath the skin and follow the course of the superficial veins, some pierce the fascia to communicate with the deep set. These drain the surfaces of the head, neck, trunk, and extremities. The deep set follow the course of the deeper bloodvessels, and drain the adjacent tissues. In the interior of the trunk the lymphatics are found in the submucous layer of the mucous membrane of the alimentary canal and respiratory apparatus, also the genito-urinary tract—kidney, bladder, etc.

The lymphatic vessels are seen as a net-work of minute vessels, larger than the capillary vessels, in the above-mentioned tissues and organs. The lymph is conveyed through these lymph capillaries to larger vessels called lymphatics, which pass to small glandular bodies called lymph nodes or lymphatic glands.

The **deep lymphatic vessels** have the same origin as the superficial set, but are fewer in number and larger. They also drain into the lymph nodes.

The lymph vessels are composed of three coats:

The **internal** is of elastic fibers arranged lengthwise, covered with a layer of endothelial cells; the **middle coat** consists of white fibrous tissue arranged longitudinally, with non-striated muscle and elastic fibers arranged transversely; the **external coat** is practically the same as the middle coat, except that the muscle fibers are arranged longitudinally.

Lymph vessels possess **valves**, which are so close together and so numerous as to appear as beads upon the course of the vessels. They face toward the larger vessels, are arranged in pairs, and are formed from a reduplication of the vessel wall reinforced by white fibrous tissue from the middle coat.

The Lymph Nodes.—They are small, solid, glandular bodies found along the course of the lymphatic vessels. They vary in size from a microscopic mass of lymphoid tissue to an olive. Their color when cut is pinkish, except in the bronchial nodes, which are black, due to the absorption of foreign particles of dust from the mucous membranes of the respiratory tract; the nodes around the liver (hepatic) are yellowish, due to the absorption of bile pigments. The splenic lymph nodes are brown.

As the lymphatic vessels from the lymph spaces approach a node they divide into numerous small vessels called **afferent vessels.** The latter pierce the capsule of the gland; devoid of their outer coat, they enter the sinus beneath the capsule, termed the **subcapsular sinus,** which communicates with a **central sinus.** The lymph is filtered within this node and is collected by small vessels which unite beneath the capsule and pierce it as a single **efferent vessel.** Upon leaving the lymph node the efferent vessel is invested by an external coat derived from the gland capsule. The lymph continues to pass on until another set of nodes are reached, when the same arrangement takes place, and so on until the large lymphatic vessels are reached, whereupon, through the thoracic ducts

and right lymphatic duct, it is returned to the venous circulation. While the lymph is in the nodes, newly formed lymphocytes attack and destroy any bacteria that are present.

Lymph nodes are divided into a superficial and deep set, and usually found around bloodvessels and embedded in fat. Occasionally they are single, but, as a rule, are found arranged in chains. Bloodvessels and nerves are plentiful. Besides these nodes, which will be classified and described later, there are structures allied to them—tonsils and Peyer's patches of the small intestines.

The Composition, Production, and Function of Lymph.—Lymph is a clear fluid found within the tissue spaces, and termed **intracellular** lymph; and in the lymphatic vessels called **intravascular** lymph. It is alkaline in reaction, and has a specific gravity of 1.02 to 1.04. When observed under the microscope, numbers of leukocytes or white blood cells are seen. These consist of a small amount of protoplasm in which can be seen a nucleus. Lymph will clot, but not as actively or as firmly as blood. The clotting is due to the appearance of fibrin.

The Chemic Composition.—This will vary, dependent upon the portion of the body drained; however, lymph obtained from the thoracic duct has been found to contain, after chemic analysis, 34 to 41 per cent. of proteins (serum-albumin, fibrinogen), 0.046 to 0.13 per cent. of substances soluble in ether (probably fat), 0.1 per cent. of sugar, and from 0.8 to 0.9 per cent. of inorganic salts, of which sodium chloride (0.55 per cent.) and sodium carbonate (0.24 per cent.) are the most abundant (Munk). Small amounts of calcium, potassium, and magnesium salts are present; also both free oxygen and carbon dioxide; urea in very small quantities. Lymph is similar in composition to the plasma of the blood, only it does not contain any red cells.

Production of Lymph.—This is still under discussion. various theories being advanced, but none are absolutely definite, nor is any accepted by physiologists as the correct one. It is supposed to be formed by the plasma of the blood passing through the thin-walled capillaries into the small lymph spaces which exist between the cells of the adjacent tissues; and another theory is that this transudation is aided by an active secretory action on the part of the endothelial cells composing the capillary walls.

This passing or transudation of the nutritive material and the white cells through the walls of the capillaries is necessary in order to have the tissues receive the elements essential for their nourishment, and to combat, with the contained lymphocytes, any invading germ, or to neutralize any toxin within the spaces. The passage of the plasma or liquid nutritive element of the blood through the capillary walls is based on three factors: namely, **osmosis, diffusion**, and **filtration.** (See standard works on physiology.)

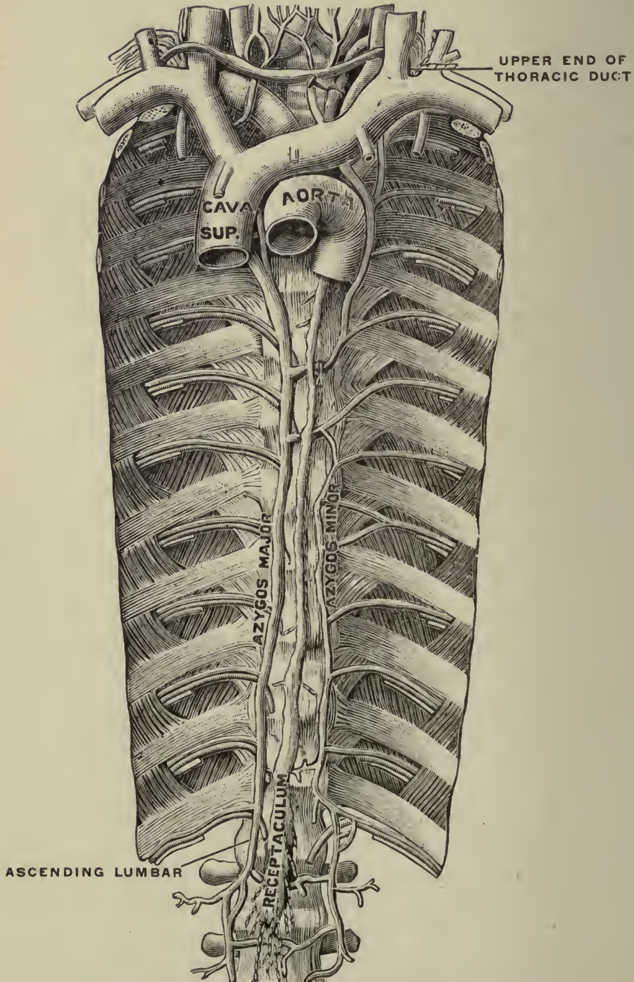
The Functions of the Intercellular Lymph.—The intimate contact of the lymph with the tissue cells of the body denotes that its function is to furnish those cells with nutritive elements essential to their growth, repair, and functional activity, and to receive from those cells the products resulting from disintegration or tissue waste as a result of body metabolism.

In order to have the lymph in relation with the tissue cells retain a certain composition, which is constantly being reduced by the absorption of the waste products into the lymph vessels and blood, it is necessary that the lymph be renewed as rapidly as consumed, and the waste material removed as produced. Should one of these conditions fail the nutritive elements of the lymph would be reduced, and consequently destroy the vitality of the tissues.

The formation of lymph is a continuous phenomena and more is formed than is essential to the needs of

the tissues to maintain their normal activities. Should the lymph be allowed to accumulate, it would lead

Fig. 89



Thoracic duct, azygos, and intercostal veins. (Testut.)

to a condition of edema and an interference with the functional activities of the tissues. But in health, before this condition of congestion is permitted, the lymphatic vessels collect the excess volume and carry it into the thoracic ducts, which convey it into the venous system.[1]

The Thoracic Ducts.—These are two in number, the right and a common trunk. They drain all the smaller lymphatic vessels of the body and open into the veins. The thoracic duct, or common trunk, drains all the vessels of the body, except the right side of the head and neck, the right upper extremity, the right side of the lung and its pleura, the heart and pericardium, and the convex surface of the liver; the latter are drained by the right thoracic duct. The common trunk begins as the **receptaculum chyli**, situated opposite the second and third lumbar vertebra behind the peritoneum. The duct is 15 to 18 inches in length. It extends from the second lumbar vertebra to the root of the neck, where it empties into the angle of junction of the subclavian and internal jugular veins. It passes through the aortic opening in the diaphragm between the aorta and the azygos vein. In the thorax it lies between the esophagus and aorta on the thoracic vertebra; upon reaching the fourth thoracic vertebra it turns toward the left and passes behind the arch of the aorta and at the seventh cervical vertebra empties into the veins as above.

The right duct is only about one-half inch in length and opens into the junction of the internal and subclavian veins in the right side.

[1] The description of the systemic lymphatic vessels and glands are not included, as they are not considered essential to a nurse's knowledge.

QUESTIONS

1. What structures are included under the lymphatic system?
2. How does the lymph reach the lymphatic vessels?
3. Where are lymph spaces found in the tissues of the body?
4. Where are the superficial set of lymphatic vessels located? Deep set?
5. In which layer of a mucous membrane are the lymphatic vessels usually found?
6. Into what structure does the lymphatic vessel drain?
7. Name the coats of a lymphatic vessel.
8. Do lymph vessels possess valves?
9. Describe a lymph node or gland.
10. What are afferent, efferent lymphatic vessels?
11. Where are lymph glands usually found?
12. What is the function of a lymph capillary?
13. What is the relation and function of blood capillaries to the lymph capillaries?
14. Give the composition of lymph.
15. How is lymph produced generally?
16. Is lymph a necessary fluid as regards the nourishment of the tissues?
17. What is the function of the thoracic ducts?
18. Where is the receptaculum chyli located?
19. What portions of the body are drained of lymph by the right thoracic duct? The left or common?
20. Into which vein does the right thoracic duct empty? The common duct?

CHAPTER X

THE RESPIRATORY APPARATUS

The respiratory apparatus consists of those organs which receive and return the air breathed through the nose, mouth, and pharynx, and convey it in a system of closed tubes and cavities to the termination of the lungs, where it comes in contact with the capillaries of the blood, which permit, owing to their thin walls and the lining membrane of the air cells of the lungs—a gaseous interchange between the carbon dioxide and other waste materials of the blood and the oxygen of the air breathed during the act of respiration.

THE ORGANS OF RESPIRATION

In man the respiratory apparatus is described under the following: **Larynx, Trachea, Bronchi,** and **Lungs.**

The organs of respiration are located as follows: The larynx and beginning of the trachea in the neck, the bronchi and lungs within the thorax.

The Nasal Cavities.—These are the proper channels for the air to pass through. However, the mouth can be used as desired by the individual, as is usually employed by persons suffering from any nasal obstruction or a deficient amount of air reaching the lungs, due to heart, lung, throat trouble, or changes in the blood which compel forced or labored breathing—**dyspnea.** The air as it passes through the nasal

cavities is warmed by coming in contact with the highly vascularized mucous membrane lining them, and thus is prevented from reaching the lungs at a low temperature, which would cause their congestion and be dangerous to health. The air also passes through the pharynx to reach the larynx.

The Larynx.—The larynx is the **organ of the voice,** and is placed at the upper and forepart of the neck, between the trachea and base of the tongue. It communicates above with the laryngopharynx, below with the trachea.

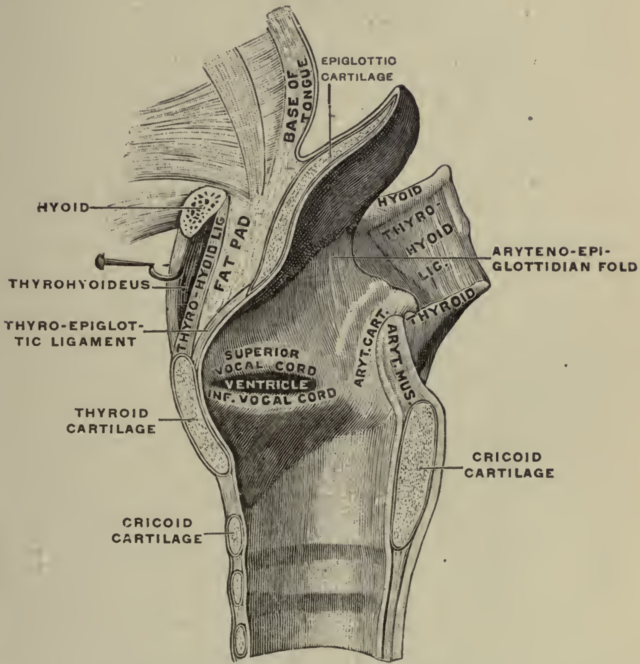
Relations.—It has on each side of it the carotid vessels, and behind it the pharynx. In front are the pretracheal portions of the cervical fascia and the upper end of the thyroid gland, and on each side the sternohyoid and thyroid and the thyrohyoid muscles. It consists of various cartilages held together by ligaments, and is lined internally by mucous membrane, continuous with that of the pharynx above and the trachea below.

The **cartilages** are nine: Three pairs, the arytenoid, cornicula laryngis, and cuneiform; and three single, the thyroid, cricoid, and epiglottis.

The **thyroid cartilage** is the largest, and consists of two lateral parts or alæ uniting in front to form the projection of the Adam's apple (pomum Adami). This is subcutaneous, more distinct above and in the male. Internally it is smooth, and in the angle the epiglottis, true and false vocal cords, and the thyroarytenoid and thyro-epiglottidean muscles are attached. The upper border is concavoconvex, and in front is notched over the pomum Adami, giving attachment throughout to the thyrohyoid membrane. The lower border is joined to the cricoid cartilage by the middle portion of the cricothyroid membrane; and on either side, affords attachment to the cricothyroid muscle. The posterior borders end in the *upper* and *lower cornua* (horns); to the upper are attached the lateral

thyrohyoid ligaments, and the lower, which are shorter and thicker, present internally a facet for articulation with the cricoid cartilage.

Fig. 90



Sagittal section of larynx, right half. (Testut.)

The **cricoid cartilage** resembles a signet ring, is narrow in front, and gives attachment to the cricothyroid muscle, and behind it to some of the fibers of the inferior constrictor. It is broad behind, with a vertical ridge for the attachment of the longitudinal fibers of the esophagus, and presents at about the middle of the lateral surface a prominence on each side which articulates with the corresponding

inferior cornua of the thyroid cartilage. The lower border is joined to the upper ring of the trachea; the upper border gives attachment in front and laterally to the cricothyroid membrane and the lateral crico-arytenoideus muscle. Behind, at each end of its upper border, is an oval surface for the corresponding arytenoid cartilage, with a notch between. The inner surface is smooth and lined with mucous membrane.

The **arytenoid cartilages** are pyramidal in form, presenting three surfaces, an apex, and base, and rest by their bases on the highest part of the upper border of the cricoid cartilage behind, their curved apices approximating.

The **cornicula laryngis** (cartilages of Santorini) are two small, cervical nodules of yellow elastic tissue, which articulate with the summits of the arytenoid cartilages and serve to prolong them backward and inward.

The **cuneiform cartilages** (Wrisberg's) are two small, yellow bodies of elastic cartilage, which stretch between the arytenoid cartilage and the epiglottis.

The **epiglottis** is a fibrocartilaginous lamella, shaped like a leaf, lying behind the tongue and in front of the upper orifice of the larynx. Above it is broad, below narrow and prolonged to the notch above the pomum Adami by the thyro-epiglottic ligament, or rather, to the angular interval just below the notch, and is attached to the upper border of the body of the hyoid bone by the hyo-epiglottic ligament. It falls downward over the opening of the larynx during the swallowing of food to prevent the same from entering the larynx.

The **ligaments of the larynx** are extrinsic and intrinsic. The former connect it to the hyoid bone; the latter connect its parts together.

The **extrinsic ligaments**, meaning those coming from without or on the outside of the larynx, are the middle thyrohyoid ligament, the two lateral thyrohyoid ligaments, and the hyo-epiglottic ligament.

The **intrinsic ligaments,** meaning those within or on the inside of the larynx, connecting the thyroid and cricoid cartilages, are the cricothyroid membrane, two capsular ligaments.

The cricoid and arytenoid cartilages are connected by loose capsular ligaments lined by synovial membranes, and by a posterior cricoarytenoid ligament running from the cricoid to the inner and back part of the base of the arytenoid.

The Interior of the Larynx (Cavum Laryngis).—This is divided into an upper and a lower part by the rima glottidis. The upper opens into the pharynx by the *upper aperture* of the larynx, between which and the rima glottidis are the ventricles and their saccules, and the false vocal cords. The lower aperture is continuous with the trachea.

The rima glottidis is the space between the true vocal cords and the bases of the arytenoid cartilages. It is somewhat less than 1 inch long, and according to its degree of dilatation, from $\frac{1}{3}$ to $\frac{1}{2}$ inch wide. In easy respiration its form is triangular with the base posterior, and when fully dilated it is lozenge-shaped.

The **superior** or **false vocal cords** are two mucous folds, each enclosing the corresponding superior thyro-arytenoid ligament. This latter is a thin band running between the angle of the thyroid and the antero-external surface of the arytenoid cartilage.

The **inferior** or **true vocal cords** are two strong bands, the inferior thyro-arytenoid ligaments, covered by mucous membrane and attached to the depression between the alæ of the thyroid cartilage in front and the anterior angle of the base (vocal process) of the arytenoid cartilages behind.

The **ventricles of the larynx** lie one on each side, between the upper and lower vocal cords, bounded externally by the thyro-arytenoidei.

The **saccule of the larynx** is a space on each side, between the false vocal cord and the inner surface

of the thyroid cartilage, reaching upward as high as the upper border of that cartilage, and its mucous membrane presents the orifices of sixty or seventy glands. This space has a fibrous capsule.

The muscles of the larynx are divided into extrinsic and intrinsic—the former will be found under the muscle system. The latter are:

Cricothyroid.	Posterior crico-arytenoid.
Thyro-arytenoid.	Lateral crico-arytenoid.
Thyro-epiglotticus.	Arytenoid (single).

Actions of the intrinsic muscles: (1) Those which open and close the glottis. (2) Those which regulate the degree of tension of the vocal cords.

1. The two posterior crico-arytenoids open the glottis; and the arytenoid and the two lateral crico-arytenoids close it.

2. The two cricothyroids regulate the tension of the vocal cords, and elongate them by the same action; the two thyro-arytenoids relax and shorten them.

Phonation, Articulate Speech.—Phonation is the phenomenon whereby the animal and human being are enabled to utter vocal sounds, due to the vibration of two elastic membranes, the vocal cords, which cross the opening of the larynx from before backward, and which are thrown into vibration by the air forced from the lungs.

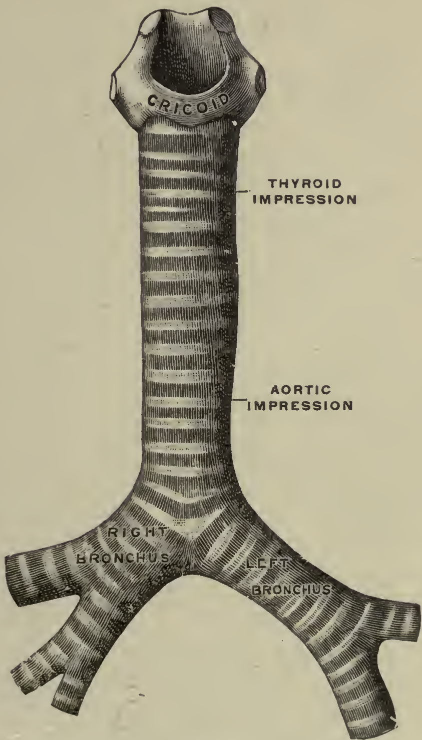
Articulate speech is a modification of the vocal sounds or the voice produced by the teeth and the muscles of the lips and tongue, and is employed for the expression of ideas (Brubaker).

The Trachea.—The trachea is a membranocartilaginous tube, flattened behind, continuous above with the larynx, and below dividing into the two bronchi.

The trachea consists of sixteen to twenty incomplete cartilaginous rings connected by a fibrous membrane.

Their free ends, which are directed posteriorly, are united similarly and by plain muscular tissue. Its upper limit is at the sixth cervical, its lower, opposite the body or upper border of the fifth thoracic vertebra,

Fig. 91



Trachea and bronchi, front view. (Testut.)

and it measures about $4\frac{1}{2}$ inches in length; transversely, $\frac{3}{4}$ to 1 inch. Its inner surface is lined by a mucous membrane which belongs to the stratified, ciliated variety of tissues, and this cilia possesses a perpetual movement, carrying the particles of dust, etc.,

entangled in the mucus toward the entrance of the respiratory tract, where it is expectorated. The submucosa contains numbers of mucous glands.

The Bronchi.—The **bronchi** enter the hilum of the corresponding lung. The right is the shorter, wider, and more horizontal, and enters the lung opposite the fifth thoracic vertebra, the larger azygos vein arching over it from behind, the right pulmonary artery below and then in front of it. The left bronchus is about 2 inches long, and enters the lung opposite the sixth dorsal vertebra. It passes under the arch of the aorta and crosses in front of the esophagus, thoracic duct, and descending aorta. The left pulmonary artery lies at first above, then in front of it.

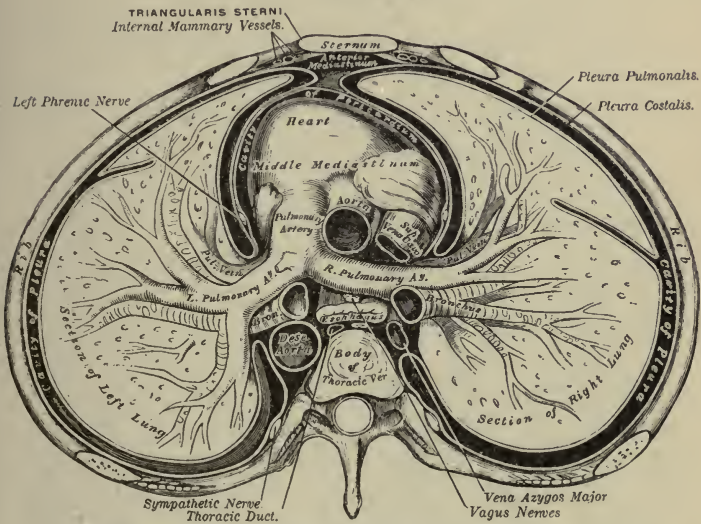
Their structure resembles the trachea, only that the cartilaginous rings become thinner and are replaced by an increase in the muscular coat, as they approach the terminal bronchioles. The alveoli, the termination of the bronchioles, rest on a basement membrane of elastic tissue, surrounded by a capillary plexus formed by the pulmonary arteries and veins.

The Pleuræ.—The **pleuræ** are two separate serous sacs which invest each lung to its root and are reflected on to the thoracic walls and pericardium. That portion of the serous membrane investing the surface of the lung and extending into the fissures between the lobes is called the visceral layer of the pleura (pleura pulmonalis), while the portion lining the inner surface of the thorax is called the parietal layer of the pleura (pleura parietalis). The latter is subdivided into the cervical, the costal, the diaphragmatic, and the mediastinal portions. The space between the visceral and parietal layers is the pleural cavity (cavum pleuræ), and contains a small amount of clear fluid. There is no cavity when the pleuræ are in a healthy condition, the two layers being in contact.

The two pleuræ are distinct from each other, and do not meet in the median line except behind the

second piece of the sternum. At the root of the lung the visceral and parietal layer of the same side are continuous, and at the lower part of the root a fold, the ligamentum latum pulmonis, runs down to the diaphragm.

FIG. 92



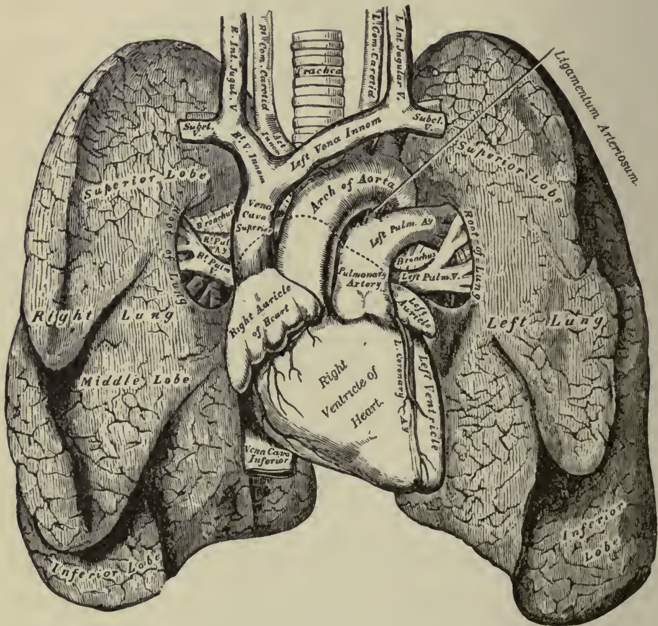
A transverse section of the thorax, showing the relative positions of the viscera and the reflections of the pleuræ. (Gray.)

The Lungs (Pulmones).—The lungs are the essential organs of respiration; they are situated in the right and left sides of the thorax, covered by the visceral portion of the pleura; filling the cavity, with the exception of the intervening mediastinum. The latter is a space within the thorax situated between the right and left lobes of the lungs; it contains the heart covered by the pericardium, the great vessels of the heart, the esophagus, trachea, bronchi, thymus gland, thoracic ducts, nerves to the heart, lungs, and other organs. It is divided into superior, anterior,

16

middle, and posterior portions, bounded above by the root of the neck, below by the diaphragm. Each lung presents for examination an apex, a base, diaphragmatic, costal, mediastinal surfaces, and anterior, posterior, and inferior borders. It is suspended within the cavity by the root and the ligamentum pulmonale.

Fig. 93



Front view of the heart and lungs. (Gray.)

During respiration the lung, covered by the visceral pleura, is pressed against the walls of the thorax, interlined by the parietal pleura, and friction is prevented by a small amount of fluid, within the pleural cavity, which continually bathes the approximating surfaces.

The apex (apex pulmonis) is rounded, and extends about 1 inch to 2 inches above the anterior end of the first rib. It is grooved by the subclavian artery on the left side, but on the right side the impression of the innominate vein is the most prominent groove seen.

Fissures and Lobes.—The left lung is divided into two lobes, an upper and a lower, by an oblique fissure, which extends from the outer to the inner surface of the lung both above and below the hilum. The right lung is divided into three lobes, an upper, middle, and lower, by an oblique fissure, separating the lower and middle lobes, a horizontal fissure separating the upper and middle lobes.

The Root of the Lung (Radix Pulmonis).—This lies a little above the centre of the mediastinal surface, and approaches nearer to the posterior than to the anterior border. It transmits the bronchus, the pulmonary artery, the two pulmonary veins, usually the bronchial arteries and veins—the former supply the bronchi and lungs with blood—the pulmonary plexus of nerves, lymphatics, the bronchial lymph nodes, and areolar tissue, surrounded by a reflection of the pleura which fuses with the pericardium at this point.

Structure of the Lungs.—The color of the lungs at birth is a pinkish white; in adult life, a dark slate color, mottled in patches; and as age advances this assumes a black color.

The lungs are composed of an external serous coat, subserous areolar tissue, and parenchyma, consisting of numbers of lobules ($\frac{1}{8}$ to $1\frac{1}{5}$ inches in size). The structures enclosed within the lungs consist of bronchi, their subdivisions which end in the air cells, blood-vessels, lymphatics and nerves, all embedded in a supporting net-work of fibrous and elastic tissue. These structures can only be seen under the microscope.

The bronchi, on passing to the periphery of the lung, become smaller and smaller as they divide and

subdivide. The walls become thinner and the cartilaginous rings disappear. The smallest bronchial tubes contain muscle tissue in their walls. These latter fibers, when stimulated by nerves from the vagus, cause a narrowing of the caliber of the bronchial tubes. When the bronchial tubes are so reduced as to measure about 1 millimeter, they are termed **bronchioles.** From the latter are given off small branches which soon expand to form numbers of lobules or **alveoli.** The central space of the alveoli is called the infundibulum, and from the inner surface of the alveolus, project small partitions which include the air sacs or cells between them. The walls of the alveolus are very thin and composed of fibro-elastic tissue. The bronchi and bronchioles are lined with ciliated epithelium and the alveoli and air cells by flat epithelial cells, called **respiratory epithelium.**

The bronchi and their subdivisions are accompanied by branches of the pulmonary artery, and pulmonary and bronchial veins. The pulmonary arteries upon reaching the alveoli of the lungs form a capillary network which is in intimate relation with the respiratory epithelium of the air sacs, only the thin wall of the capillary intervening. This permits of the ready interchange of the carbon dioxide through the wall of the capillary and respiratory epithelium with the intrapulmonary air, and the oxygen from the latter is absorbed in the same way by the red cells of the blood in the pulmonary capillaries, and returned to the left side of the heart. The bronchial arteries supply the walls of the larger bronchial tubes and tissue of the lungs anastomosing with the capillaries of the bronchial and pulmonary veins. The bronchial veins pass back to empty into the azygos system on the right side and on the left they drain into the superior intercostal vein. The pulmonary veins are supposed to contain some venous blood derived from the bronchial venous capillaries, besides their arterial blood.

RESPIRATION

Respiration is a process whereby the lungs receive the oxygen from the air we breathe; it is carried to the tissues by the hemoglobin of the red cells, where it is given off to the tissues; carbon dioxide is taken up by the hemoglobin from the tissues and carried by the red cells to the lungs, where it is given off in the expired air. Respiration, therefore, is a function indispensable to life and plays a most important part in the maintenance of body metabolism, by supplying oxygen to the tissues, and removing carbon dioxide from the tissues in the chemic interchange taking place between the air, the blood, and the tissues during the act of respiration, and circulation of the blood.

Rate of Respiration.—The normal rate of respiraation varies at different ages as follows: At birth and during the first year, 44 per minute; five years, 26 per minute; fifteen to twenty years, 20 per minute; twenty to twenty-five years, 18.7 per minute; thirty to fifty years, 18 per minute.

Respiration is divided into: **inspiration**, an active process due to muscular activity, when air enters the lungs, due to atmospheric pressure being greater than the contained intrapulmonary; **expiration**, a quiet or passive process, due to the recoil of the elastic tissue of the lungs, the abdominal and thoracic walls; when the intrathoracic pressure becomes greater than the atmospheric air pressure it allows the contained air to escape until the intrapulmonary pressure equals the atmospheric air pressure, then inspiration occurs again, and the respiratory cycle is repeated.

The Volumes of Air Breathed.—This is determined by an apparatus known as Hutchinson's spirometer. With this apparatus four volumes of air are determined. (1) The **tidal** volume or the amount of air which flows into and out of the lungs during an ordinary

inspiration and expiration varies from 20 to 30 cubic inches. (2) The **complemental** volume or the amount of air taken into the lungs, in addition to the tidal volume, resulting from a forcible inspiration, which amounts to 110 cubic inches. (3) The **reserve** volume or the amount of air which flows out of the lungs, in addition to the tidal volume resulting from a forcible expiration, which amounts to 100 cubic inches. (4) The **residual** volume or amount of air remaining in the lungs, as a permanent volume, after the most forcible expiration.

The **vital capacity** is the amount of air which can be expelled from the lungs after they are filled by the most forcible inspiration. This amounts to 230 cubic inches (3593 c.c.).

Changes in the Composition of Inspired and Expired Air as a Result of Respiration.

Inspired Air, 100 Volumes

Oxygen	20.80
Carbon dioxide	traces
Nitrogen	79.20
Watery vapor	variable

Expired Air, 100 Volumes

Oxygen	16.02
Carbon dioxide	4.38
Nitrogen	79.60
Water vapor	saturated
Organic matter	

(Brubaker)

The above analyses show that the air under ordinary conditions loses oxygen to the extent of 4.37 per cent., and gains in carbon dioxide to the extent of 4.38 per cent.; it gains in nitrogen to the extent of 0.4 per cent., and watery vapor to the point of saturation, also organic matter.

From experiments with the spirometric apparatus, and the taking of the percentage loss of oxygen and gain in carbon dioxide shown by the analysis of the

respired air, it is possible to figure approximately the total amount of oxygen absorbed and carbon dioxide given off during respiration. The minimum daily volume of air breathed is assumed to be 10,800 liters and the maximum daily volume 12,240 liters. Thus the minimum daily volume of oxygen absorbed is 516 liters, maximum 585 liters. Carbon dioxide is exhaled amounting to 473 liters, the minimum daily volume; 526 liters, the maximum daily volume.

Thus one can readily understand how essential it is for human beings to obtain a fresh supply of air to breathe in order to maintain life and carry on its various activities. Since during every breath the external air loses oxygen and gains carbon dioxide, besides other waste products, the air in dwellings, offices, etc., should be frequently renewed in order to maintain a condition of health. If we take in at each inspiration 30 cubic feet of air, and breathe at the rate of 18 respirations a minute, then in twenty-four hours 450 cubic feet (12.8 cm.) will pass in and out of the lungs. Thus it is easy to understand how a person laboring, or sleeping, etc., in an unventilated room would readily succumb, theoretically, by rebreathing the poisoned air from his own lungs.

The Changes in the Blood during Respiration.—The blood as it is forced from the right ventricle of the heart through the pulmonary artery to the lungs, is dark bluish red in color. On reaching the air cells of the lungs the blood becomes bright red in color and is carried through the pulmonary veins to the left auricle, then into the left ventricle of the heart, when it passes out through the large artery (aorta) to supply the body tissues.

The blood is changed while flowing through the capillaries from the venous to the arterial state. When the dark bluish-red blood in the pulmonary arteries reaches the capillaries of the pulmonary system where they surround the air cells, and the thin membrane

separating the capillaries from the intrapulmonary air, the carbon dioxide is given off and the oxygen is taken up and combines chemically with the hemoglobin contained in the red cells, forming **oxyhemoglobin**, the blood in the arterial capillaries of the pulmonary veins immediately turns bright red as a result of the interchange. This bright red or arterial blood is carried to the tissues by the arteries and capillaries.

Fig. 94

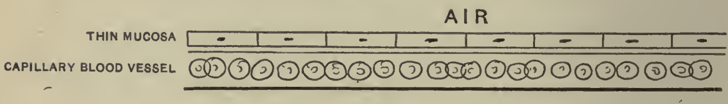


Diagram of the essentials of a respiratory apparatus. (F. H. G.)

This power possessed by the blood of absorbing and giving up oxygen and carbon dioxide through the capillary walls from and to the air and tissues respectively is based on the well-known fact that liquids will absorb or dissolve at any constant pressure unequal volumes of different gases in accordance with their solubilities, and with variations in temperature (Brubaker).

The Relation of the Nerve System to Respiration.—The rhythmic movements of respiration are controlled by nerve impulses which arise in groups of nerve cells in the central nerve system, and are transmitted to the **inspiratory** and **expiratory** centres in the medulla oblongata, which are stimulated into activity.

The inspiratory and expiratory centres are included under the term **respiratory centre.**

The vagus nerve is the important nerve which transmits nerve impulses from the inspiratory centre in the medulla to the lungs. It contains **excitor** and **inhibitor** fibers; the former, when stimulated, increase the rate of inspiration and the latter decrease it.

Respiration is believed to be due to a stimulus resulting from the alternate distention and collapse of the walls of the pulmonary alveoli—a mechanic action.

The inspiratory centre can be influenced directly by nerve impulses being transmitted from the brain in response to voluntary acts, or emotional states, sighing, etc., also indirectly by nerve impulses reflected to the centre from the surfaces of the skin and mucous membranes through afferent nerves; as cold applied to the skin, irritating gases to the nasal and bronchial mucous membranes, and collapse or distention of the pulmonary alveoli.

QUESTIONS

1. Name the organs of respiration.
2. What effect has the nasal mucous membranes upon the air we breathe?
3. What is dyspnea?
4. What is the organ of the voice?
5. Give the relations of the larynx.
6. How many cartilages form the larynx? Name them.
7. Which cartilage forms the Adam's apple?
8. What is the rima glottidis?
9. Describe the true and false vocal cords.
10. Which muscles open the glottis? Close it?
11. Which muscles regulate the tension of the vocal cords? Relax them?
12. What do you understand by the term phonation?
13. How is articulate speech produced?
14. Name the number of rings in the trachea.
15. What variety of epithelium lines the trachea and what is its function?
16. Are there glands in the trachea, and to what variety do they belong?
17. Where do the bronchi enter the lungs?
18. Are the pleuræ closed sacs?
19. What do you understand by the terms visceral and parietal pleura?
20. Where is the pleural cavity located? Does it contain fluid?
21. What membranes cover the lung?
22. Name the parts of each lung.
23. What structures form the root of the lung?
24. How many lobes has the right lung? The left?
25. Give the microscopic structure of the lung.

26. What is a bronchiole? Lobule?

27. Where is the infundibulum in the lobules of the lungs? The air sacs?

28. Name the variety of epithelium lining the bronchi, bronchioles, alveoli, and air sacs.

29. What relation do the capillaries of the pulmonary artery and vein bear to the air sacs of the lobules?

30. What relation do the respiratory epithelium and capillaries bear to respiration?

31 Describe respiration.

32. Give the normal rate of respiration per minute at birth. Five years. Fifteen to twenty years. Twenty to twenty-five years. Thirty to fifty years.

33. Name the divisions of respiration.

34. What do you understand by the terms tidal volume? complemental volume? reserve volume? residual volume? in relation to respiration?

35. What is the average vital capacity of the lungs? What is meant by it?

36. Give the minimum and maximum daily volume of air breathed.

37. What gaseous interchange takes place during each respiration between the hemoglobin of the red cells and the air we breathe?

38. How is the color of the blood affected by respiration?

39. Where is the oxygen absorbed at each respiration carried to? Where does the carbon dioxide in the blood come from to be given off at each respiration?

40. What centre in the medulla controls inspiration and expiration?

CHAPTER XI

THE ORGANS OF DIGESTION

THE digestive apparatus for the digestion of the food we eat consists of the **alimentary canal** and **accessory organs.**

The **alimentary canal** is a musculomembranous tube, about thirty feet in length, extending from the mouth to the anus, and lined by mucous membrane throughout the entire length.

It is divided in different parts according to the mechanical or chemical changes taking place during the various stages of digestion: as the **mouth,** where the **teeth, tongue,** and **salivary glands** perform the act of mastication and insalivation; the **pharynx** and **esophagus,** which receive, force, and convey the food to the stomach, as in the act of swallowing or deglutition; the **stomach,** in which the chief chemical changes occur and the food is reduced to a semiliquid condition, to be passed on to the small intestines; the **small intestines,** where it is acted upon by the bile, pancreatic and intestinal juices which separate and render absorbable the nutritive material; the **large intestines,** to which that portion of the food which is unabsorbable moves on to pass out through the rectum and anus as fėces or waste particles.

The accessory organs of digestion are: the teeth, tongue, salivary glands—parotid, submaxillary, and sublingual—the liver and pancreas.

The **alimentary canal** consists of the following:

Mouth.		Duodenum.
Pharynx.	Small Intestine	Jejunum.
Esophagus.		Ileum.
Stomach.		Cecum.
	Large Intestine	Colon.
		Rectum.
		Anal canal.

THE MOUTH, ORAL OR BUCCAL CAVITY

The **mouth** is the upper part of the alimentary canal. It is bounded by the lips, cheeks, tongue, hard and soft palate, alveolar processes of both jaws, with their contained teeth, and opens behind, through the isthmus faucium, into the pharynx. It is lined by mucous membrane continuous in front with the skin, behind with that of the fauces, its epithelium being stratified.

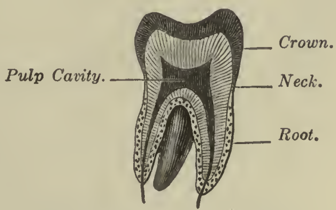
The Teeth.—The **teeth** in the human subject are erupted in two sets, a temporary or deciduous, or milk teeth, and a permanent or succedaneous set. The former are 20 in number, 10 in each jaw; the latter, 32, 16 each above and below. Each tooth is made up of three parts: the root, consisting of one or more fangs, contained in the alveolus; the crown or body, above the gum; and the neck, between the two. The alveolar periosteum is reflected on to the fang as far as the neck.

The **twenty temporary teeth** are divided into 4 incisors, 2 canines, and 4 molars above and below. The 32 *permanent* teeth are: 4 incisors, 2 canines, 4 bicuspids, and 6 molars in each jaw. The temporary teeth are similar to but smaller than the permanent; of the temporary molars, the hinder one is the largest of

all, and its place is afterward taken by the second permanent bicuspid.

Of the **permanent teeth** the **incisors** are the 8 central cutting teeth, 4 each above and below, the former being the larger. They are bevelled at the expense of the posterior surface. The canines (*cuspidati*) are 2 in each jaw, being situated 1 behind each lateral incisor, the upper and larger being called the eye teeth. The bicuspids (*premolars* or *false molars*), 4 in each jaw, lie 2 each behind the canines, the upper being the larger. The **molars** (*true molars* or *multicuspidati*) are the largest teeth, and number 6 in each jaw, 3 each behind the posterior bicuspids above and below. They present 4 tubercles on the upper, 5 on the lower crowns, and the root is subdivided into from 2 to 5 fangs. The first molar is the largest and broadest, the second smaller, and the third (wisdom tooth) the smallest.

FIG. 95



Vertical section of molar tooth.

A **vertical section of a tooth** shows it to be hollow, the cavity being continuous with the aperture in the fang and filled up with the soft dental pulp, and is hence called the pulp cavity. The pulp is sensitive, highly vascular, and consists of connective tissue, with cells, vessels, and nerves. The hard substance of each tooth consists of three parts: the *ivory* or *dentin*, the *enamel*, and the *crusta petrosa* or *cement*.

The period of eruption of the temporary teeth are (C. S. Tome):

Lower central incisors	6 to 9 months
Upper incisors	8 to 10 months
Lower lateral incisors and first molars	15 to 21 months
Canines	16 to 20 months
Second molars	20 to 24 months

The period of eruption of the permanent teeth are:

First molars	$6\frac{1}{2}$ years
Two middle incisors	7th year
Two lateral incisors	8th year
First bicuspid	9th year
Second bicuspid	10th year
Canine	11th to 12th year
Second molars	12th to 13th year
Third molars	17th to 21st year

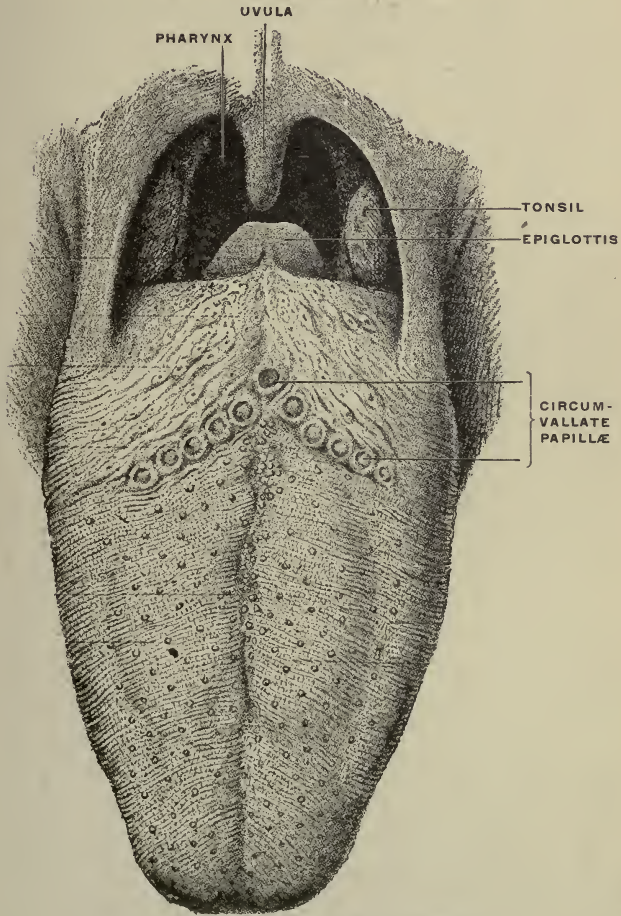
The Tongue (Lingua).—The tongue is the organ of the special sense of taste,[1] also assisting in insalivation, mastication, deglution, and articulate speech. It is situated in the floor of the mouth, in the interval between the horizontal rami of the mandible. It is attached to the hyoid bone at the base by the genioglossus and hyoglossus muscles and the hyoglossal membrane; with the epiglottis by three folds, the glosso-epiglottic folds, of mucous membrane; with the soft palate by means of the anterior pillars of the fauces; and with the pharynx by the superior constrictor muscles and the mucous membrane.

The muscles controlling the tongue are the extrinsic, which are inserted into the tongue, their terminal fibers contained within the substance, namely, the styloglossus, the hyoglossus, the palatoglossus, the genioglossus, and part of the superior constrictor of the pharynx (pharyngoglossus). The intrinsic muscles of the tongue are: the superior lingualis, the chondroglossus, the transverse lingualis, the vertical lingualis, and the inferior lingualis.

[1] See chapter Sense of Taste, page 406.

The arteries of the tongue are derived from the lingual, the facial, ascending pharyngeal (all branches of the external carotid artery). The veins open into the internal jugular. The lymphatic vessels from the

Fig. 96



Dorsal surface of the tongue. (Testut.)

anterior half of the tongue drain into the submaxillary nodes. Those draining the posterior half end in the deep cervical nodes; along the internal jugular vein.

Nerves of Tongue.—(See Nerve System, pages 374 and 406.)

The Palate.—The **palate** forms the roof of the mouth, and consists of a front part or hard, and a back part or soft palate. The periosteum of the hard palate (see Bones) is covered by and intimately connected with the mucous membrane of the mouth. In the middle line is a raphé ending in front at a small papilla, which marks the anterior palatine fossa which receives the terminal part of the anterior palatine and nasopalatine nerves. The mucous membrane is pale and corrugated, covered with squamous epithelium, and furnished with a number of palatal glands which lie between it and the bone.

The **soft palate** partially separates the mouth and pharynx. It consists of muscular, connective, and adenoid tissue, with vessels, nerves, and mucous glands, all enclosed in a fold of mucous membrane. Above it is joined to the back of the hard palate; laterally it blends with the pharynx; below it is free; in front it is concave, with a median ridge; and behind it is convex. Its mucous membrane is continuous with that of the roof of the mouth and of the posterior nares.

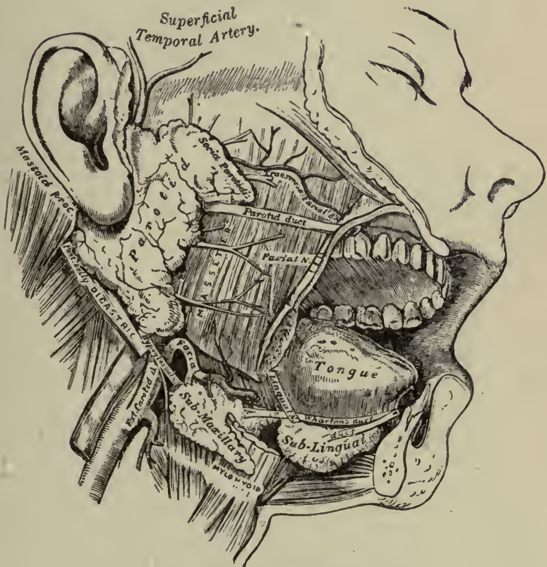
From its lower border a conical process depends, the *uvula,* from whose base descend the *pillars* of the soft palate, the anterior, formed by the *palatoglossi muscles,* to the sides of the base of the tongue; the posterior, formed by the *palatopharyngei,* to the sides of the pharynx. These pillars are covered by mucous membrane and separated below by the tonsil, the space being called the isthmus of the fauces.

The **tonsils** (tonsilla palatina) are two in number, situated on each side of the fauces, and lie between the anterior and posterior palatine pillars, and are about $\frac{1}{2}$ inch long and $\frac{1}{3}$ inch wide and thick, but vary much in size.

The Salivary Glands.—There are three pairs, *parotid, submaxillary,* and *sublingual.*

The **parotid gland**, the largest, weighs $\frac{1}{2}$ to 1 ounce, and lies on the face below and in front of the ear. Its outer surface, lobulated, is covered by the skin and fascia, and partly by the platysma and several lymphatic glands.

FIG. 97



The salivary glands. (Gray.)

The *duct* (Stenson's) is about $2\frac{1}{2}$ inches long and $\frac{1}{8}$ inch in diameter, and opens opposite the second molar tooth, into the mouth, thence runs backward beneath the mucous membrane, through the buccinator, and across the masseter to the front of the gland. It conveys the saliva to the mouth.

The **submaxillary gland** is of an irregular form, weighs about 2 drams, and lies below the jaw and above the

digastric muscle. It is covered by the skin, platysma, and fasciæ, and grooves the inner surface of the lower jaw.

The *submaxillary duct* (Wharton's) is 2 inches long, and opens at the top of a papilla close to the frenum of the tongue into the mouth. Thence it runs back between the sublingual gland and the geniohyoglossus, then between the mylohyoid and the hyoglossus and geniohyoglossus.

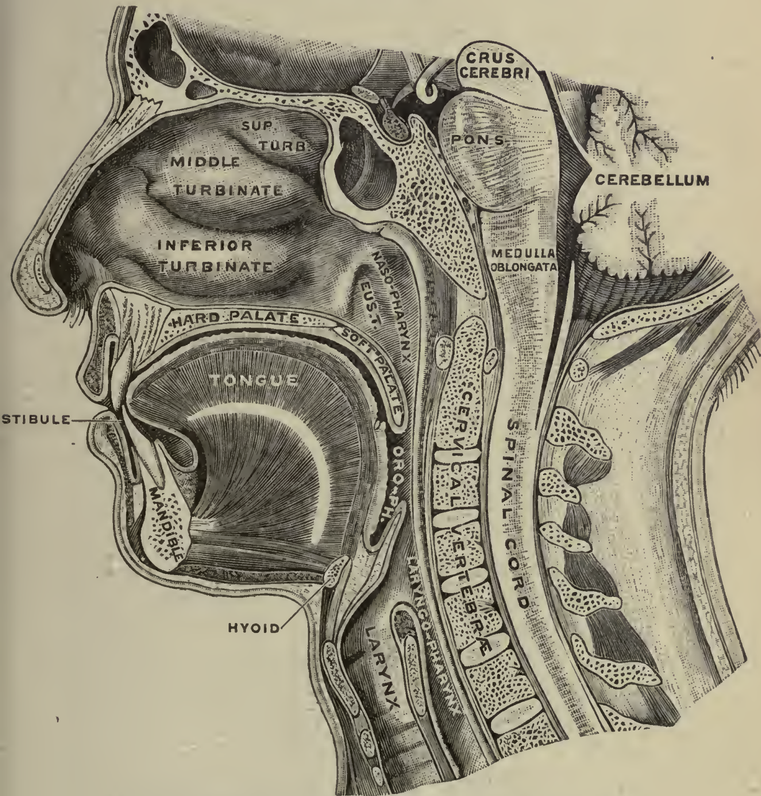
The **sublingual gland,** the smallest of the salivary glands, lies at the side of the frenum of the tongue and against the inner surface of the lower jaw, beneath the mucous membrane. It is almond-shaped, weighs 1 dram, and its ducts (*of Rivini*), ten to twenty in number, open separately, one or two joining to form the duct of Bartholin, which joins Wharton's duct.

THE PHARYNX

The pharynx is a musculomembranous tube, conical in shape, between the oral cavity and the esophagus; communicating with the posterior nares, the oral cavity, the larynx, the two Eustachian tubes. It is attached above to the periosteum of the petrous portion of the temporal bone and the basilar process of the occipital bone. The raphé of the constrictor muscles is attached to the pharyngeal tubercle of the basilar process of the occipital bone. It is bounded above by the body of the sphenoid and basilar process of the occipital; below, it is continuous with the esophagus; anteriorly, it is incomplete, and is attached to the Eustachian tube, the internal pterygoid plate, the pterygomandibular ligament, the posterior portion of the mylohyoid ridge, the mucous membrane of the mouth, the base of the tongue, the hyoid bone, the thyroid and cricoid cartilages; posteriorly, the prevertebral fascia, and areolar tissue connect it to

the cervical portion of the vertebral column, anterior to the longus colli and rectus capitis anticus muscles, the areolar tissue is contained in the retropharyngeal

FIG. 98



Sagittal section of face and neck, showing external wall of right nasal fossa. (Testut.)

space; laterally, it is connected to the styloid process and its muscles. The constrictor muscles surround it and aid in deglutition. It is $4\frac{1}{2}$ inches long, and for

purposes of studying, divided into a nasal, oral, and laryngeal portion.

The nasal part or nasopharynx, lies posterior to the nares and above the soft palate. In front are the posterior nares (choanæ); behind, the pharyngeal tonsil, consisting of lymphoid tissue seen above the orifices of the Eustachian tubes in the median line. The floor of the nasopharynx is continuous with the nasal fossæ, anteriorly, and behind is the sloping portion of the soft palate. On its lateral wall is the orifice of the Eustachian tube, level with the inferior turbinated bone and one-third to one-half inch posterior.

The oral part extends from the soft palate to the level of hyoid bone. It opens into the oral cavity, through the fauces, bounded on either side by the anterior and posterior pillars, between which are the tonsils.

The laryngeal part is continuous with the oral portion above, and below at the level of the cricoid cartilage is continuous with the esophagus. Anteriorly, it presents the aperture of the larynx, bounded in front by the epiglottis, and laterally by the aryteno-epiglottic folds.

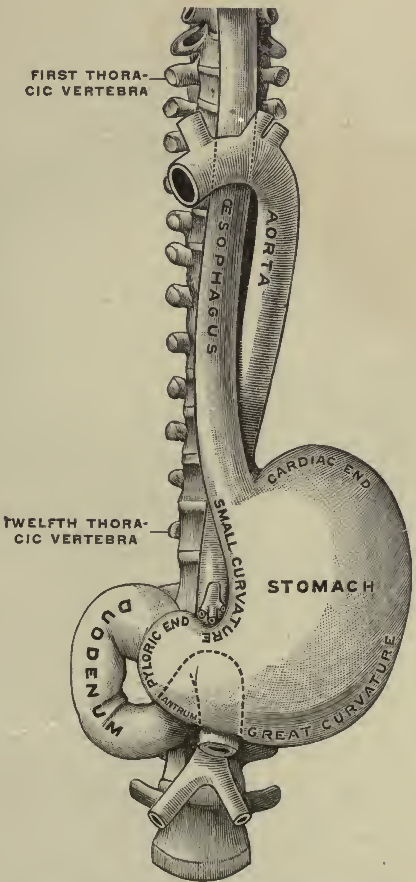
The pharynx is lined with mucous membrane continuous with that lining the Eustachian tube, the nasal fossæ, the mouth, and the larynx. In the nasopharynx it is covered by stratified ciliated epithelium; in the oral and laryngeal portions it is of the stratified squamous variety.

THE ESOPHAGUS (GULLET)

The **esophagus** is the tube connecting the pharynx with the stomach, and extends from the level of the sixth cervical vertebra through the diaphragm, entering the stomach opposite the tenth or eleventh dorsal

vertebra, a distance of 9 or 10 inches, and from the incisor teeth to the beginning of the esophagus is about 6 inches; thus making the distance from the

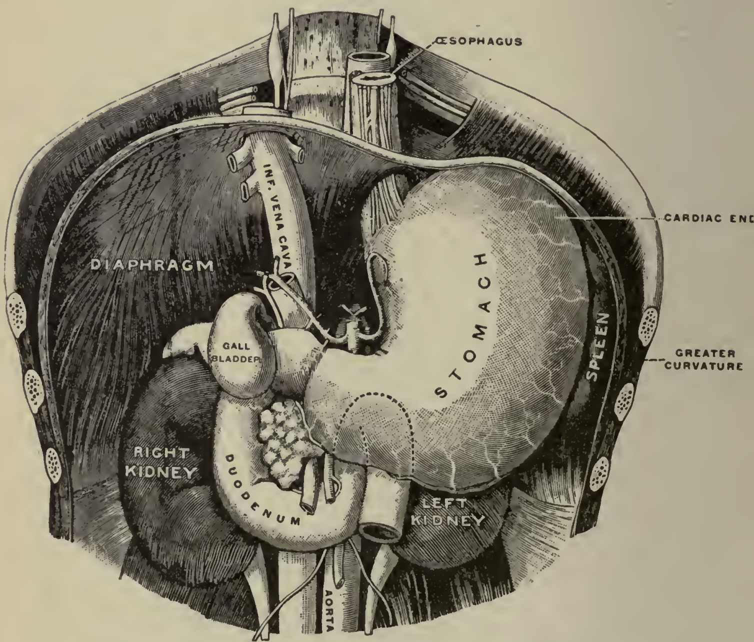
Fig. 99



Esophagus and stomach in their natural relations to the vertebral column and the aorta. (Testut.)

incisor teeth to the cardiac opening of the stomach 15 to 16 inches. It is the narrowest part of the alimentary canal, and presents two constrictions, one at its commencement, the other at the diaphragm.

Fig. 100



Stomach and duodenum, the liver and most of the intestines having been removed. The pyloric end of the stomach should be represented as turned directly backward. (Testut.)

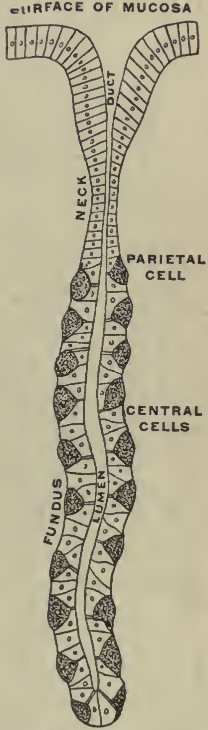
THE STOMACH (GASTER)

The stomach lies in the epigastrium, left hypochondrium, and sometimes the mesogastrium. It is the most dilated portion of the alimentary canal. Its shape is pyriform, the left or larger portion is

called the **cardia,** and below this is the **fundus,** the right end is termed the **pylorus.** The right opening of the stomach is called the **pyloric orifice,** and the left the **esophageal orifice,** the former opens into the duodenum, and the latter, the esophagus. It is 10 to 12 inches in length, 4 to 5 inches in the vertical direction, and weighs 4 to 5 ounces. Its capacity is from 3 to 6 pints.

The **cardiac orifice** is the highest **part of the stomach,** and lies behind the seventh costal cartilage, 1 inch to the left of the sternum. The **pyloric orifice** lies about 2 inches to the right of the midline, on a level with the upper border of the first lumbar vertebra; it is guarded by a valve, the pylorus. Between the two orifices the stomach is sickle-shaped and presents an upper concave border, the **lesser curvature,** and a lower convex border, the **greater curvature.** The pyloric orifice is anterior and inferior to the fundus and is in relation with the quadrate lobe of the liver and belly wall. The stomach presents two **surfaces,** an **anterosuperior** and **postero-inferior.**

Fig. 101

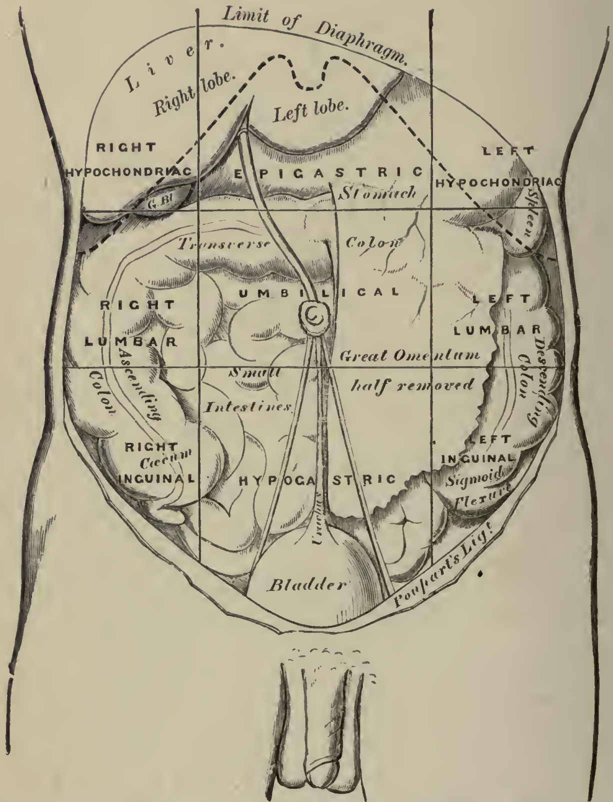


Cardiac gland in longitudinal section. (F. H. G.)

The stomach has a *serous* (peritoneal) coat, a *muscular* coat comprising a longitudinal, circular, and oblique layer, an *areolar* coat of loose tissue (submucous coat), and a *mucous* coat, lined with columnar epithelium. The latter is thickest near the pylorus, thinnest at

the fundus, and presents, in the empty condition of the organ, numerous ridges or *rugæ*, which run longi-

Fig. 102



The regions of the abdomen and their contents. Edges of costal cartilages in dotted outline. (Gray.)

tudinally along the great curvature. Studded over its surface are many small polygonally shaped depressions which are the enlarged mouths of the gastric

tubular glands. These are of two kinds, called pyloric and cardiac glands—they secrete the gastric juice; some are simply tubular, while others have several branches opening into a common duct. The *pyloric glands* are most numerous at the smaller end, but the *cardiac glands* (see Fig. 101, page 263) are found all over the stomach, the ducts of the latter being shorter. In the cardiac glands, between the basement membrane and the lining epithelium, are numerous peptic or parietal cells, the others being known as the central or chief cells. Between the glands the mucous membrane contains lymphoid tissue, collected here and there into little masses resembling the solitary intestinal glands, and called the lenticular glands. Beneath the membrane is a muscularis mucosæ. (See Fig. 82, page 202, for blood-supply of the stomach.)

THE SMALL INTESTINE

The Duodenum.—The **duodenum** is about 10 inches long, and runs in a curved direction from the pylorus of the stomach to the jejunum, which it joins on the left side of the second lumbar vertebra. The concavity of the curve looks toward the left and embraces the head of the pancreas. It is divided, for description, into four parts or portions.

The Jejunum and Ileum.—The *jejunum* includes the first two-fifths of the remaining part of the small intestine, running from the left side of the first or second lumbar vertebra to the beginning of the ileum. Its coats are thicker and more vascular, and are of a deeper color and larger caliber than the ileum.

The remainder of the small intestine is the *ileum,* which ends by opening into the inner side of the commencement of the large gut in the right iliac fossa.

The Structure of the Small Intestines.—The wall of the small intestine, including the duodenum, con-

sists of a serous, a muscular, a submucous, and a mucous coat.

The Serous Coat.—This is derived from the peritoneum and surrounds the bowel completely, except in the duodenum, where only the first portion is completely covered. Along its mesenteric border, where the mesentery (a fold of peritoneum) is attached, is an uncovered interval for the entrance and exit of arteries, veins, nerves, and lymphatics which pass between the layers of mesentery.

The Muscular Coat.—This consists of an outer longitudinal and an inner circular set of muscle fibers. These muscular layers propel the food along the intestines, as well as assist by their action in mixing it with the intestinal juices during active digestion.

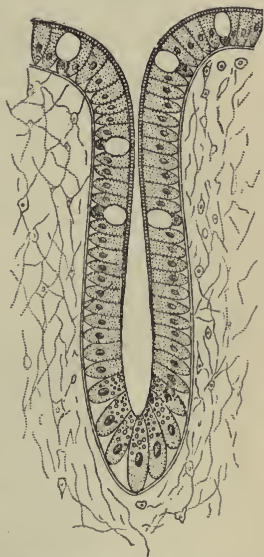
The Submucous Coat.—This is composed of areolar tissue and holds the mucous and muscular coats together. It contains the branches of the nutrient arteries to the bowel, previous to their distribution to the mucous coat, also the lymph channels and nerves. The lymph nodules are lodged in this layer; they are pear-shaped with their apex lying in the mucous membrane. These are called **solitary follicles** and **Peyer's patches.** The submucous coat in the small intestines extends up into the valvulæ conniventes. In the duodenum the duodenal glands are lodged in the submucous coat.

The Mucous Membrane.—This is lined with columnar epithelium. It is soft and velvety in appearance. The membrane is highly vascular near the beginning of the duodenum, and gradually becomes paler as the lower portion of the bowel is reached. The membrane is thrown into folds called **valvulæ conniventes.** Each fold is simply two layers of membrane folded upon itself and held together by fibrous tissue. They increase the absorbing surface of the intestinal canal and retard the progress of the food, according to some authors. They measure $\frac{1}{4}$ to $\frac{1}{2}$ an inch in width, and

extend to about one-half to two-thirds of the circumference of the bowel. The villi in the mucous membrane are described under absorption (see page 287).

The Intestinal Glands or Glands of Lieberkühn.—These are found in the mucous membrane throughout the small intestines. They are minute tubular depressions seen at the base of the villi and communicate with the surface of the mucous membrane, upon which they pour out a special secretion from the columnar cells which line them; the latter rest on a thin basement membrane, which is surrounded by capillary vessels.

Fig. 103



Intestinal gland in longitudinal section. (Testut.)

The Duodenal or Brunner's Glands.—They are found only in the duodenum. They are small, branched, tubular glands situated in the submucous coat and open upon the mucous membrane of the duodenum by very small ducts.

The Lymph Nodules.—They are divided into **solitary follicles** and **Peyer's patches.** Their bodies are in the submucous coat and their apices in the mucous membrane.

The **solitary follicles** are found throughout the mucous and submucous layers of the small and large intestines. They are small, round, whitish collections of areolar tissue rich in leukocytes or white corpuscles, and blood capillaries, and communicate through their base with the lacteals of the villi. Each consists of a lighter, central area, the germinal centre, where the leukocytes are reproducing, and an outer darker zone,

where the cells are more numerous and closely packed (Gray).

FIG. 104

Duodenal gland. (Frey.)

FIG. 105

Aggregated lymph nodule (Peyer's patch). (Testut.)

Peyer's patches are regarded as collections of solitary follicles, seen as oval or rounded patches, placed

lengthwise with the bowel, measuring from ½ to 4 inches in length. Usually ten to sixty are present. They are found mostly in the ileum. Peyer's patches are highly inflamed in typhoid fever, and ulcerate, giving rise to hemorrhage and perforation of the bowel in severe attacks of the disease. (See Fig. 83, page 204, for blood-supply of the small intestines.)

THE LARGE INTESTINE

The large intestine is that part of the alimentary canal which extends from the end of the ileum to the anus; it is about 5½ feet long. It commences by a dilated part, the *cecum,* in the right iliac fossa, ascends to the under surface of the liver, then runs transversely across the abdomen to the vicinity of the spleen, descends to the left iliac fossa, and forms the sigmoid flexure, and finally passes along back of the pelvis to end at the anus.

The Cecum.—The **cecum** is the large cul-de-sac which is the beginning of the large intestine, and is about 3 inches broad and 2¼ inches long. It is variously situated, being found upon and external to the psoas; upon the iliacus muscle it lies internal, on the pelvic brim, or entirely within the pelvis. In any of these positions it is entirely surrounded by peritoneum.

The **vermiform appendix** comes off from the inner and back part of the cecum, near its lower end, and extends upward and inward behind it. This is a piece of gut of the diameter of a goose-quill, varying from 3 to 6 inches in length, curved upon itself, and ending in a blind extremity. It tapers gradually to its end, which is blunt, is completely invested by the peritoneum, which forms for it a mesentery (meso-appendix), and at its connection with the cecum is guarded by an imperfect valve (**valve of Gerlach**). This is not always constant.

The **ileocecal valve** guards the opening of the small

intestine into the large gut. This junction is oblique and situated about $2\frac{1}{2}$ inches above the lower extremity of the cecum. It is a double fold lying transversely to the long axis of the colon. Each fold of the valve is made up of the mucous and submucous coats, reinforced by some circular fibers from the muscular coat, of each portion of the gut, and is covered on the side toward the ileum with villi.

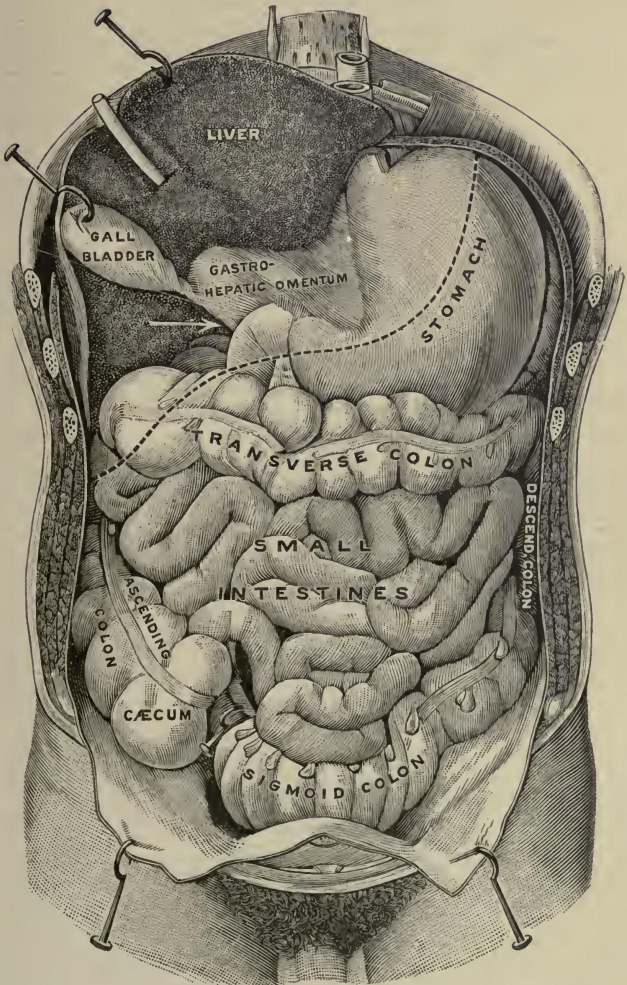
The Colon.—The **ascending colon** runs from the cecum, above the ileocecal valve, upward to the under surface of the liver on the right side of the gall-bladder, and then turns forward and to the left to form the *hepatic flexure*. The peritoneum rarely forms for it a mesocolon; generally it covers only the front part and the sides. It occupies the right lumbar and hypochondriac regions.

The **transverse colon** arches across the abdomen, the convexity looking toward the belly wall, and makes a sudden turn backward and downward beneath the spleen, forming the *splenic flexure*, and is completely invested by the peritoneum, which holds it to the anterior aspect of the pancreas and second portion of the duodenum; by two layers of peritoneum called the transverse **mesocolon,** the upper surface of which fuses with the posterior layer of the great omentum. It occupies the right hypochondriac, upper part of umbilical, and left hypochondriac regions. At the splenic flexure is attached the *phrenocolic ligament*, a fold of peritoneum extending to the diaphragm opposite the tenth or eleventh rib.

The **descending colon** descends from the splenic flexure, to end at the left iliac fossa in the sigmoid flexure. It is covered in front and laterally by the peritoneum. It occupies the left hypochondriac and lumbar regions.

The **sigmoid flexure** ends in the rectum. From the end of the descending colon it forms an S-shaped curve, ending opposite the left sacro-iliac joint. In

Fig. 106



The stomach and intestines, front view, the great omentum having been removed, and the liver turned up and to the right. The dotted line shows the normal position of the anterior border of the liver. The dart points to the foramen of Winslow. (Testut.)

front of it are the belly wall and some coilsof small intestine. The peritoneum forms a loose mesocolon for it. It is the narrowest part of the colon.

The Rectum.—This is the lowest part of the large intestine, and extends from the sigmoid flexure to the anus. It has been divided into three parts: the first part extends from the left sacro-iliac joint to the centre of the third piece of the sacrum; the second part, to the tip of the coccyx; and the third part, to the anus.

The rectum is about 8 inches long and somewhat cylindrical in form, narrower above than the sigmoid flexure, but it enlarges as it descends, and just above the anus is remarkably dilated, forming the ampulla. The first part has a mesorectum; the second part is covered by peritoneum in front and laterally; the third part has no peritoneal covering.

The cul-de-sac of Douglas (rectovaginal pouch) is the space in front of the rectum and behind the cervix of the uterus and upper fourth of the vagina. It is formed by the peritoneum reflected over the rectum to the vagina and uterus. In the male it is the space formed between the rectum and bladder, and is called the **rectovesical space** or **pouch.**

The Structure of the Large Intestine.—The large intestine has three coats comprising its wall: A **serous, muscular,** and **mucous.** Its mucous membrane does not possess the **valvulæ conniventes** nor villi; it is lined by columnar epithelium, and contains a large number of tubules lined by columnar epithelium; they resemble the glands of Lieberkühn, and secrete a viscid fluid, rich in mucin. (See Fig. 83, page 204, for blood-supply of the large intestines.)

QUESTIONS

1. What is the length of the alimentary canal?
2. What organs constitute the alimentary canal?
3. How many temporary teeth are there in the child? Permanent teeth in the adult?
4. Name the parts which form a tooth.
5. How are the temporary teeth divided as to name and number? The permanent teeth?
6. Give the position in the alveolar processes of the incisor teeth. The canines. The bicuspids. The molars.
7. Give the period of eruption of the temporary teeth. The permanent teeth.
8. What are the functions of the tongue?
9. What do you understand by the hard palate? The soft palate?
10. What is the isthmus of the fauces?
11. Give the location of the tonsils.
12. Name the salivary glands.
13. Which salivary gland is the largest? Give the weight of each.
14. When do the salivary glands pour out their secretions? And through what structure?
15. What structures does the pharynx communicate with?
16. How long is the pharynx, and what three parts is it subdivided into?
17. Which variety of epithelium lines the three portions of the pharynx?
18. What organ connects the pharynx with the stomach?
19. What is the distance from the incisor teeth to the cardiac opening in the stomach?
20. Name the portions of the stomach.
21 What orifices are found in the stomach and with what organs do they communicate?
22. How many borders and surfaces has the stomach?
23. Give its dimensions, weight, and average capacity.
24. Name the coats of the stomach wall.
25. How are the fibres in the muscular coat arranged?
26. Name the glands found in the membrane of the stomach.
27. What structures secrete the gastric juice?
28. Where are the pyloric glands in the stomach located? The cardiac glands?
29. Do the cardiac and pyloric glands communicate with the internal surface of the stomach? Through what structure is their secretion poured out?
30. Name the cells formed in a cardiac gland.
31. How long is the duodenum?
32. What portions of the alimentary canal does the duodenum connect and communicate with?
33. What are the divisions of the small intestine called?
34. Name the coats forming the structure of the small intestine.
35. Which variety of the epithelium lines the small intestine?

36. What are the valvulæ conniventes? What is their function?
37. Where are the glands of Lieberkühn found? Glands of Brunner?
38. Do the above glands communicate with the surface of the mucous membrane of the intestines?
39. Where are solitary lymph follicles found? Peyer's patches?
40. Describe a Peyer's patch.
41. How long is the large intestine?
42. What is the length of the appendix?
43. Name the portions of the colon.
44. How long is the rectum?
45. What is its lower opening called?
46. Name the coats of the large intestine.
47. What type of epithelium is present in the large intestine?
48. Are valvulæ connivents found in the large intestine?
49. Does the mucous membrane of the colon contain glands?
50. What variety of secretion do the glands of the colon secrete?

CHAPTER XII

DIGESTION

The digestive apparatus consists of the entire alimentary canal, including the mouth, pharynx, esophagus, stomach, small intestines—duodenum, jejunum, ileum; large intestines—cecum, colon, rectum; and the accessory organs, as the teeth, salivary glands, tongue, gastric and intestinal glands, the pancreas, and liver.

Mastication and Insalivation.—**Mastication.**—This is the process whereby the food is chewed or undergoes a mechanic disintegration, which permits of it being properly acted upon by the saliva and formed in such condition to be swallowed; this is brought about by the action of the teeth, tongue, and muscles of mastication, which act upon the lower jaw, bringing it with the contained teeth against the upper teeth in the maxilla.

Insalivation.—This is the mixing of the food with the saliva during the act of mastication. The saliva is constantly bathing the mucous membranes of the oral cavity and its contents; however, during mastication there is a marked increase of this complex fluid secreted from the salivary glands—parotid, submaxillary and sublingual, and palatine glands in the roof of the mouth.

The Saliva.—This is a complex chemic fluid composed of the mixed secretions of all the salivary glands. It is a frothy, slightly turbid, viscid fluid. Its reaction under normal conditions is alkaline. It may be neutral or acid in some individuals, in which fermen-

tation is going on from decayed teeth or particles of food lying in the recesses of the teeth and mouth, or disorders of digestion. Under the microscope, the saliva will show epithelial cells, salivary corpuscles resembling white corpuscles, particles of food, and various microörganisms (germs).

The Physiologic Actions of Saliva.—The constant presence of saliva in the mouth is essential to the process of digestion. It has a double duty to perform, called **physical** and **chemical.**

Physically the mucin present in the saliva forms the particles of food into a consistent mass after the food has been softened and moistened while mastication has been going on, and renders it in such shape to be swallowed (deglutition).

The Chemical Action of Saliva.—Its main property is the changing or converting of starch into sugar by the means of a starch-changing ferment or enzyme, which is supposed to belong to the group of proteins, called **ptyalin,** in the saliva.

Deglutition (the act of swallowing).—This is a complicated function due to the action of the muscles of the tongue, soft palate, pharynx, and esophagus acting upon the food, called a bolus after it has been chewed or masticated by the teeth, whereupon these structures force it from the mouth into the pharynx and thence through the esophagus into the stomach.

At the beginning of deglutition the mouth is closed and the tip of the tongue is rested against the incisor teeth. There is a temporary suspension of respiration. The tongue arches from before backward against the roof of the mouth, due to the action of the intrinsic muscles, those contained therein, and forces the bolus of food through the opening leading from the mouth to the pharynx. These actions are under the control of the will. The food upon reaching the pharynx is seized by the constrictor muscle of this organ and by a sphincter action is forced through the

esopahgus, which continues this muscular wave (peristaltic wave). Some physiologists say that the food passes through the pharynx and esophagus due to a rise in pressure. Food as it passes into the pharynx would enter the nasal cavities and larynx, but the former cavities are closed by the action of the tensor palate and levator palati muscles which contract and draw upward and backward the palate until it meets the posterior wall of the pharynx. The larynx is closed from the food, for just at the time of or before deglutition there is a temporary suspension of inspiration, and the larynx is drawn up under the base of the tongue and the opening to it closed by the epiglottis falling downward and backward, preventing food from entering the larynx.

Gastric Digestion.—The digestion of the food on reaching the stomach is a further step in its gradual preparation into a more liquid or semiliquid form to enable the capillaries and lymph vessels within the villi of the small intestines to absorb it after being acted upon by the intestinal and pancreatic juices in the small intestines.

The walls of the mucous membrane of the stomach between the periods of active digestion are being bathed with an alkaline secretion derived from the glands in its wall. This secretion of the gastric juice has been produced reflexly by psychic influences, such as the sight of food, and is also due to an irritation of the mucous membrane produced by the presence of food in the stomach. After digestion has commenced this secretion is profuse. The bloodvessels of the mucous membrane become congested and the glands show activity. The perpetual secretion of gastric juice is supposed to be due to some chemic change taking place, the resultant substance acting as a specific stimulant to the cells of the glands.

When food passes through the cardiac orifice due to the peristaltic waves and pressure within the esoph-

agus during deglutition or swallowing. The stomach receives the food, whereupon the muscular fibers of the cardiac and pyloric orifices close by a sphincter-like contraction. The food is held within the stomach for a few moments, then is turned over and over and moulded by the muscular contractions of the stomach until it is reduced to a liquid or semiliquid consistency called **chyme,** by the action of the gastric juice. The pyloric portion of the stomach becomes shaped like a tube, and the fundus or most dilated portion of the stomach contracts and forces the food (chyme) into the duodenum, where it is conveyed by a similar peristaltic contraction of its walls into the small intestine. There is no given time for emptying the stomach. As the food is liquefied it is forced out of the stomach and then the semisolid particles of the diet which are not digested by gastric juice are passed from the stomach, leaving it empty except for the alkaline secretion which is mucous, and protects its walls. Digestion in the stomach lasts from two to five hours, depending upon the food, quantity and quality, pathologic conditions, etc. No nourishment is absorbed by the lymph or bloodvessels of the stomach.

Gastric Juice.—Under normal physiologic conditions gastric juice is a thin, almost colorless liquid, with a characteristic odor and acid reaction. The average of acidity varies; normally it is 0.02 per cent. The acidity is due to the presence of hydrochloric acid, and in certain conditions of health and disease, lactic acid may be found. As a result of disease, the acidity may be increased, decreased, or entirely absent. The gastric juice contains in addition to the above, **pepsin** and **rennin,** two proteolytic ferments or enzymes; the former is active only in an acid medium, and the latter is the ferment which curdles milk or divides it into a solid portion, casein, and the liquid portion, whey. The chemic nature of these enzymes is unknown.

Gastric juice also contains, in addition, large amounts of water, ammonium, calcium, potassium, and sodium chlorides; calcium, magnesium, and ferric phosphate are present in small amounts.

Pepsin converts proteins into peptones. The process is most complicated and, as described by Kühne in his investigations, is as follows: The protein material is changed first into acid-albumin. If the solution is rendered alkaline, acid albumin will be precipitated. Then the acid albumin is split up into several soluble proteins called, collectively, primary proteoses: albumose from albumin, globulose from globulin, etc. The latter in turn take more water and split up into another group of proteins called secondary proteoses or deuteroproteoses. The latter undergo further change and form peptones.

Rennin curdles cows' milk very rapidly at the body temperature. The casein in the milk is changed from a soluble protein into a solid clot which finally becomes firm and squeezes the whey out of the mass. The curd of cows' milk is a solid clot, whereas the curd of human milk is formed into very fine particles, thus rendering it more digestible to the infants.

Intestinal Digestion.—Upon reaching the small intestine the chyme containing the partially digested fats, meats, sugars, the peptones, etc., is acted upon by the pancreatic and intestinal juices, and bile, all at the same time; the action of each of these juices will be considered individually. As these partially digested particles are acid in reaction, as they pass through the intestines they cause a reflex stimulation of its cells which pour out an alkaline secretion.

The Pancreatic Juice.—This is secreted by the cells of the glands of the pancreas and reaches the duodenum by way of the pancreatic duct (Wirsung), which opens into the small intestines, together with or ahead of the bile from the liver, and is supposed to be mixed

with the bile and food material at the same time. It is alkaline in reaction, and contains three active enzymes—**trypsin, amylopsin,** and **steapsin.**

Trypsin is a more active ferment than pepsin, and continues the digestion of peptones into a more soluble form than pepsin. It acts best in an alkaline medium. The function of this ferment is to convert proteins into peptones, as pepsin does in the gastric digestion.

Amylopsin is the ferment in the pancreatic juice which converts the undigested particles of starch in the food into sugar—maltose. It acts similarly to the ferment ptyalin in the saliva. As starch digestion ceases with the entrance of food into the stomach, the action of the amylopsin ferment in the pancreatic juice is important, in order that the starches are completely digested, for they belong to the carbohydrates which are essential as a food, to be used by the tissues in the production of heat and energy.

Steapsin is the ferment or enzyme which splits the fats remaining in the partially digested food into fatty acids and glycerin. The fatty acids coming in contact with alkaline salts in the intestine are saponified and form a soap, the products are absorbed and combine again to form a neutral fat, which is used by the tissues after absorption. This recombination may occur in the epithelial cells of the intestines. Some of the fat is emulsified during the formation of the soap, appearing as a creamy emulsion, before being absorbed.

Intestinal Juice.—We have described or endeavored to make clear how the food we eat has been gradually reduced to a state in which it can be absorbed—liquid or semiliquid. There still remains, as has been proved in animals and human beings, chyme in the intestines, containing sugars, apparently non-absorbable without undergoing further change. This is produced by the action of the intestinal juice and the contained enzyme or ferment **invertin.** The latter converts these sugars—

saccharose, maltose, and lactose—into dextrose and levulose, two varieties of sugar which are assimilable. These two sugars together form what is called invertin sugar.

The Part Played by the Bile in Digestion.—The liver plays a large part in digestion and nutrition of the body. This important relation is due chiefly to the secretion from the liver cells termed **bile.**

Bile is continually secreted from the cells within the lobules of the liver, and is collected by the tiny biliary capillaries which join larger vessels to finally end in the right and left hepatic ducts which leave the transverse fissure of the liver, passing downward after receiving the cystic duct from the gall-bladder, and then pass downward and inward as the common bile duct to open into the duodenum. The bile is stored in the gall-bladder until needed, when it passes through the above-mentioned passages to aid in the intestinal digestion of the food.

Bile obtained from the gall-bladder is of a thick, viscid character, green or golden yellow in color, specific gravity of 1.010 or 1.020. It is composed chiefly of water, small quantities of sodium glycocholate, and sodium taurococholate, cholesterin, free fat, sodium palmitate and stearate, lecithin, other organic matters; sodium and potassium chlorides, sodium and calcium phosphates, sodium carbonate.

The flow of bile from the liver is continuous, influenced by the process of digestion. It increases as soon as food reaches the stomach, but its greatest flow is not noted until about two hours later. After this it decreases by degrees, but never entirely stops. The bile is forced out of the gall-bladder by a contraction of its muscular walls.

The Physiologic Functions of the Bile.—(1) Aids in digestion of fats, and by its contained bile salts increases the action of the pancreatic enzymes in splitting neutral fats, digesting starches and peptones;

(2) arrests gastric digestion, by neutralizing and precipitating the proteins which have not been entirely digested; and by preparing the way for intestinal digestion; (3) a slight antiseptic action. It is a known fact, that if bile is not secreted in the human being, putrefactive changes take place, with the resultant formation of foul gases, and other products noted in the feces; (4) increases peristalsis, which aids in the proper contractile movements of the walls of the intestines, favoring intestinal digestion and defecation.

The Functions of the Large Intestine.—The large intestine is that portion of the bowels which commences at the ileum and terminates at the anus. Its subdivisions are termed: the cecum, ascending, transverse, descending, and sigmoid colon, and the rectum. It is a large musculomembranous tube covered externally by the peritoneum, and is from $4\frac{1}{2}$ to 5 feet in length in a normal adult.

The contents of the colon consist of the undigested products of digestion, as a result of the food being acted upon by the saliva, gastric, pancreatic, and intestinal juices, and the bile; the nutritive parts, peptones, fatty acids, glycerin, etc., being absorbed; the resulting liquid and waste material contains undigested particles of cereals, vegetables, seeds, cellulose, etc., which are passed into the rectum by a peristaltic wave of its walls similar to the phenomena taking place in the small intestines, then expelled from the rectum during the act of defecation.

The mucus secreted by the glands of the large bowel incorporates the liquid material and passes it toward the sigmoid flexure of the colon, where it is held prior to the emptying of the bowel.

Defecation.—This is the act whereby the waste material resulting from digestion is expelled from the intestine by the rectum and passes through the anus. It occurs normally once a day. The walls of the sigmoid colon contract and force the feces

into the rectum. This gives rise to the sensation felt prior to defecation, then the longitudinal and circular fibers of the rectum contract, and pressing downward on the mass, force it through the relaxed sphincter ani muscles. The wall, contraction of the diaphragm, the muscles of the abdomen levator ani and coccygeus, sphincter ani muscles all aid in the expulsion of the feces.

Digestion in Infants.—The Saliva.—This is very scanty at birth, but gradually increases. At the fourth month it is of sufficient quantity and of such strength as to be capable of digestion. When the teeth are erupted there is a marked increase in saliva, and from the eighth to tenth month it will digest a small amount of starch.

The Capacity of the Stomach.—It is essential for the nurse to acquire a knowledge of the capacity of the infant's stomach from birth to the fourteenth month. The following capacities may vary somewhat, and the nurse's judgment must influence her in certain cases if called upon to prepare a bottle for the baby, in regard to the quantity of modified milk to be used in each feeding (according to Holt):

Age.	Average capacity.
Birth	1.20 ounces
Two weeks	1.50 ounces
Four weeks	2.00 ounces
Six weeks	2.27 ounces
Eight weeks	3.37 ounces
Ten weeks	4.25 ounces
Twelve weeks	4.50 ounces
Fourteen to eighteen weeks	5.00 ounces
Five to six months	5.75 ounces
Seven to eight months	6.88 ounces
Ten to eleven months	8.14 ounces
Twelve to fourteen months	8.90 ounces

Gastric Digestion.—Breast-fed babies retain the milk in the stomach for about an hour after nursing, bottle-fed babies about one hour and a half; this

increases with age. In the very young the stomach is simply a reservoir for the food, when it is passed into the small intestine. Pepsin has been found in the infant's stomach, and some hydrochloric acid, which accounts for its acidity. And in early life some lactic acid.

Rennin plays an important part in infant digestion. It is the ferment which coagulates mothers' and cows' milk, splitting the casein into a solid mass (clot), and whey (the liquid portion). Intestinal digestion is not very active in infancy, the ferment from the pancreas acting more like ptyalin in the saliva of the adult. Absorption of nourishment takes place from the mucous membrane of the intestines. In breast-fed infants 2 to 5 per cent. of the fat and protein pass directly through the intestines; in bottle-fed ones, 1 to 3 per cent. more for the fats, and a still greater increase for the proteins (Appelmann). Numerous bacteria are present in the intestinal canal of infants. They may play some part in digestion; however, it is one on which neither life nor health depends.

QUESTIONS

1. What organs constitute the digestive apparatus?
2. Describe mastication; insalivation.
3. Name the glands which secrete saliva.
4. Is the reaction of saliva acid or alkaline?
5. Describe the physiologic (physical) action of saliva; chemical.
6. What change takes place in the bloodvessels of the mucous membrane of the stomach during digestion?
7. What part do the muscular coats of the stomach play during digestion?
8. How is the food held within the stomach while the walls contract upon it?
9. What do you understand by the term chyme?
10. How long does digestion last in the stomach?
11. What juice is secreted from the glands of the mucous membrane of the stomach during digestion?
12. Do the blood or lymph vessels absorb any nourishment from the stomach?
13. Is gastric juice acid or alkaline in reaction during digestion?

14. What is the acidity due to? What percentage of hydrochloric acid is normally present in the gastric juice?

15. What is the function of pepsin in the gastric secretion? Rennin?

16. Is the intestinal secretion acid or alkaline in reaction?

17. Name the enzymes found in the pancreatic juice.

18. Give briefly the function of the enzymes trypsin, amylopsin, steapsin, as regards their action during intestinal digestion.

19. Name the enzyme present in the intestinal juice and give its function.

20. What cells secrete the bile and how does it leave the liver?

21. Name the organ in which bile is stored.

22. How does the bile reach the intestine from the liver and gall-bladder?

23. Give the physiologic functions of bile.

24. Give the contents of the colon following intestinal digestion.

25. Give the capacity of the infant's stomach at birth; two, four, six, eight, ten, twelve, fourteen to eighteen weeks; five to six, seven to eight, twelve to fourteen months.

26. Describe the functions of the stomach during gastric digestion in infants.

27. In which portion of the alimentary canal is the nourishment absorbed from during infant digestion?

CHAPTER XIII

ABSORPTION

Absorption is the process whereby the nutritive material, lymph, is transferred from the tissues; the serous cavities—pericardium, peritoneum, etc.; and mucous membranes into the blood. The lymph is absorbed from the mucous membrane of the alimentary canal, as it is the principal source of nutritive material used by the body for the maintenance of the quantity and quality of the blood; while the lymph absorbed from the serous cavities and tissues represents a reabsorption of the nutritive materials which have escaped through the capillary walls, and are returned to the veins through the lymphatic vessels. Were this lymph allowed to collect in the tissues, there would occur an excessive accumulation, and this condition would be readily accounted for in the swelling of the subcutaneous tissue and organs giving rise to a pathologic condition termed **edema.**

Under the chapter on digestion it was shown how the food we eat is reduced to a liquid condition by the action of the various gastric, pancreatic, and intestinal juices and their ferments. This nutritive material is taken up by the mucous membrane of the intestine and absorbed, then reaches the blood-current by way of the lymph channels—lacteals, and finally reaches the thoracic duct; or by way of the venous capillaries of the mesenteric veins, and is carried to the liver, and thence to the right side of the heart.

Before understanding the methods of food absorption, a description of the mucous membrane of the intestines is necessary.

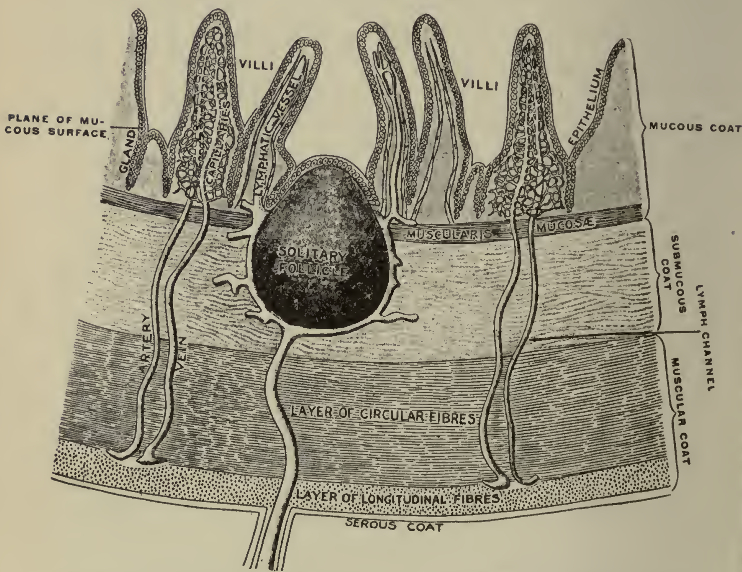
Structure of the Villi.—The mucous membrane of the small intestine is covered by tiny conical processes which extend from the end of the pylorus of the stomach to the end of the ileum. These, when examined under the microscope, show a conical process covered with columnar epithelial cells, each cell containing a nucleus, and here and there goblet cells which secrete mucus. The epithelial cells rest upon a basement membrane. In the body of the villus that portion within the mucous membrane contains a net-work of connective tissue supporting arterioles, capillaries, venules, and lymphatic vessels. In the centre of the villus is a lymph capillary, usually single, with epithelial cells in its wall.

The Function of the Villi.—The action of the cells of the villi during digestion is to absorb the nutritive products of digestion. These products are taken from the intestinal canal and transferred into the lymph spaces within the body of the villi, from which they are finally taken up by the blood capillaries and lymphatics. There are two routes by which the nutritive material passes into the general blood stream. The capillaries which enter the villi and are in intimate relation with the lymph space give up their nutritive materials (blood plasma) by a transudation through their walls, which forms the lymph; meantime the nutritive material absorbed from the intestines by the cells of the villi undergoes metabolic changes and enters the arterial capillaries from the lymph spaces. This renourished blood in the arterial capillaries passes into the venules and then into the larger veins of the intestines, to be conveyed to the liver, which uses it to maintain its functions. The lymph contained in the lymph spaces within the villi is called **chyle** (a milk-white fluid), which is absorbed by the lymphatic vessels called **lacteals**, and these empty into the large mesenteric lymphatics to drain

into the thoracic duct, and the latter communicates with the left subclavian vein, and thus returns the excess of lymph back to the blood-stream.

The wonderful aspect of absorption is the apparently unsolvable problem in regard to how these numbers of cells in the villi of the intestinal mucous membrane

FIG. 107



Mucosa of small intestine in ideal vertical cross-section. (Testut, after Heitzmann.)

can absorb the different constituents of the nutritive materials from the alimentary canal and transfer them into the lymph spaces to be absorbed by the blood capillaries and lymphatics.

It is supposed to be due to a "selective action" based on their organization and living condition, an action which is to a great extent conditioned and

limited by the degree of diffusibility of the substances to be absorbed (Brubaker's *Physiology*, p. 225).

QUESTIONS

1. Describe absorption.
2. By what two sources does lymph reach the blood current?
3. What is the function of the cells in the villi of the mucous membrane of the small intestines?
4. Where are the lymph spaces found?
5. What do you understand by the term lacteals?
6. What is chyle?
7. How does the nutritive material absorbed by the cells of the villi reach the arterial capillaries? Where is this material conveyed?
8. Where is the lymph absorbed by the lacteals from the lymph spaces conveyed?
9. Name the vessels found in a villi.

CHAPTER XIV

SECRETION

Secretion is a term applied to a process by which a portion of the constituents of the blood are separated from the blood-stream, by the activities of the endothelial cells of the capillary walls, as the blood flows through the capillaries. In this process the endothelial cell is aided by the physical forces—diffusion, osmosis, and filtration. The materials thus separated are collectively termed lymph (Brubaker).

These secretions are utilized and adapted to many and complex functions, dependent upon the secretory organ which secretes the fluid and the membrane it is poured out upon. They enable the tissues of the body to repair, grow, and produce heat and energy. Others are to promote digestion, etc., remove foreign bodies (dust, etc.) from membranes, as the conjunctiva, to prevent friction between the serous membranes, as the pericardium, pleura, and peritoneum; and to prevent friction between the extremities of the bones entering into the formation of the joints, as the fluid in synovial membranes.

Secretions are divided into **internal** and **external** secretions. **Internal secretions** are fluids secreted by the epithelial cells of certain organs of the body which do not possess any ducts by which their secretion is poured into any cavity or organ, but is reabsorbed into the blood, and the contained specific constituents aid in the nutrition of the body. These organs are: the thyroid, thymus, adrenal, spleen, pituitary glands, hypophysis, etc. (See description of the Ductless Glands, page 303.)

External secretions are fluids of a definite consistency and known function which, when secreted by the epithelial cells and poured from the organ by means of a duct or ducts on to the membrane they are to bathe, etc., perform this given activity. Such secretions are: the saliva, mucus, milk, gastric juice, sebaceous matter, etc.

The epithelium lining the secretory organs have a general similar histologic arrangement, and resemblance; however, the difference in the constituents of the secretion is supposed to be based upon their ultimate chemic structure.

The epithelial secretory organ consists of a thin, delicate membrane lined on its functionating surface by a layer of epithelial cells and on the outer side by a net-work of capillary bloodvessels, lymph vessels, and nerves.

The epithelial secretor organs are subdivided into: (1) **secreting membranes**; (2) **secreting glands.**

THE SECRETING MEMBRANES

These are the membranes lining the pulmonary and gastro-intestinal tracts, the genito-urinary tracts, and the serous membranes lining closed cavities, such as the pleural, pericardial, peritoneal, and synovial membranes.

The secretion from the various epithelial cells lining mucous membranes possesses different composition, according to the locality. It is called **mucus,** a pale, semitransparent, alkaline fluid containing white cells and epithelial cells. Chemically it consists of water, mineral salts, and a protein mucin. Most of the mucus is secreted by the goblet cells. Mucus is classified according to where secreted, as nasal, bronchial, vaginal, urinary, and gastro-intestinal.

The **serous membranes** are practically large lymph

spaces and the contained fluid is practically lymph. It diminishes friction when the organs they enclose rub against one another.

Synovial membranes secrete a fluid resembling lymph, but it also possesses a protein—a mucin-like substance, which renders it viscid. Synovial membranes prevent friction between adjacent surfaces of bone entering into the formation of joints.

The other secretions of the body, as the aqueous humor of the eye, gastric secretions, etc., will be described under the physiology of the parts.

THE SECRETING GLANDS

These are a group of cells given off as a pouch from the mucous membrane or skin, and communicating with the lining membrane or surface the secretion is to act upon by means of an open passageway, called a duct. Their epithelial cells vary in their structure and function dependent on their location. The epithelial cells of the secretory glands are surrounded by a net-work of blood capillaries, lymph vessels, and nerves; the nerves are in direct connection with the epithelial cells and bloodvessels.

How these epithelial cells absorb from the lymph and blood plasma their essential constituents of the secretions and change them into their different chemic and physiologic fluids is not definitely known, except that they are the result of metabolic processes going on within the cells.

All secretory glands are controlled by nerve centres situated in the central nerve system. Normal secretions of glands are brought about by a reflex action. In all reflexes there must be a sensitive surface to receive the impression (skin, mucous membrane, etc.), an afferent nerve (one which transmits the impression to the centres in the brain), an efferent nerve (one which transmits the return stimulus to

a responsive organ—in this case the cells of the secretory organ or gland).

The active discharge of the secretion from the cells is interrupted by periods of rest, during which time, if they be examined under the microscope, after the absorption of lymph, they will show accumulations within themselves of their characteristic products as globules of mucin — granules which are the basic formation of the digestive ferments or enzymes, granules of glycogen, globules of fat, sugar, and protein, as in the case of the mammary gland.

Excretion is a process similiar to secretion, the only difference being that the fluids removed are the waste products from the cells formed as a result of metabolism.

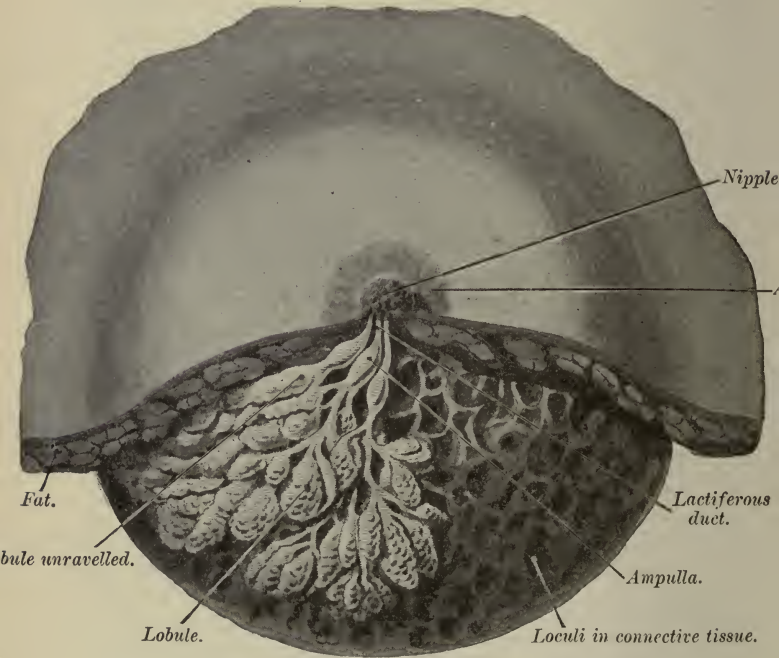
The Mammary Glands.—These are accessory to the reproductive system and secrete the milk. They are two rounded eminences, one on each side of the thorax, between the sternum and axilla and the third and seventh ribs. Just below the centre is a conical eminence, the nipple, which is dark, and is surrounded by a pinkish **areola** which darkens in pregnancy. It presents the orifices of the **lactiferous ducts,** and consists of vessels mixed in with plain muscular fibers,. and by friction may be made to undergo erection.

The **mamma** consists of a number of lobes separated by fibrous tissue and some adipose tissue. The lobes are divided and subdivided into smaller lobules, which are in turn made up of alveoli. Each lobe has an excretory (galactophorous) duct, and these, about sixteen in number, converge to the areola, there dilating into **ampullæ** or sinuses. They then become smaller again, and surrounded by areolar tissue and vessels, pass through the nipple to empty on the surface by separate orifices.

Milk.—Milk as obtained from the breast during active secretion or lactation is an opaque, bluish-

white fluid, without any oder, sweetish in taste, alkaline in reaction, and has a specific gravity of from 1.025 to 1.040. Examined microscopically it presents a clear fluid called the **plasma,** which holds in suspension great numbers of oil globules. The

FIG. 108



Dissection of the lower half of the female breast during the period of lactation. (From Luschka.)

amount of milk secreted each day by a healthy woman averages about 1200 c.c. Milk is the most important of the animal foods, containing all the elements necessary to properly nourish and develop the body, and is used as a food.

Differences in chemical composition of human and cows' milk (Holt):

	Woman's milk average per cent	Cows' milk average per cent.
Fat	4.00	4.00
Sugar	7.00	4.50
Proteins	1.50	3.50
Salts	0.20	0.75
Water	87.30	87.25
	100.00	100.00

By the above it will be seen that cows' milk has an excess of proteins and salts, and is deficient in sugar.

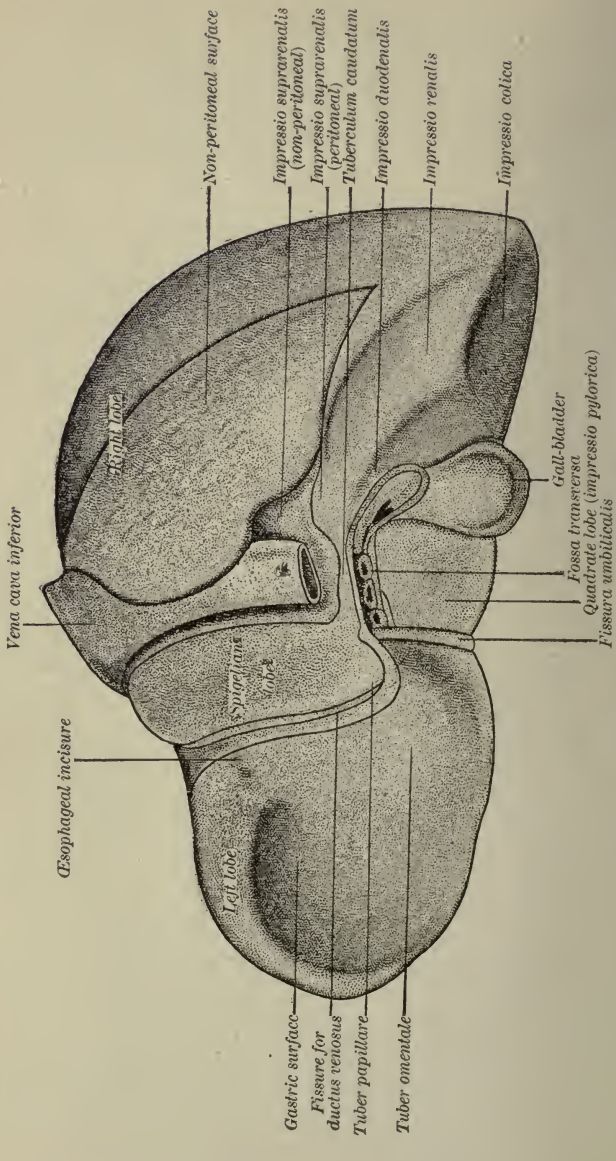
The secretion of milk is influenced by emotional states, both as to quantity and quality, due to some connection between the nerve centres and the gland cells.

Colostrum.—This is the first fluid secreted by the breasts after the birth of the infant. It is a liquid which resembles milk, and contains epithelial cells, fat globules, colostrum corpuscles. Colostrum is richer than the milk, containing more lactose and inorgânic salts. According to some authors it contains compounds which act as a laxative to the newborn.

The Liver (Hepar).—Description of the Liver.—The liver is the largest gland of the body, and fills the entire hypochondrium, the greater portion of the epigastrium, sometimes extending into the left hypochondrium. It weighs from 50 to 60 ounces in the male; 40 to 50 ounces in the female. Constitutes one-eighteenth of the body weight in the adult, and one-thirty-sixth of the body weight in the fetus. It measures, transversely, from 8 to 9 inches; antero-posterior, 4 to 5 inches, and vertically, near its right surface, about 6 or 7 inches. Its specific gravity is 1.05.

The liver presents a **superior surface** which includes the right and left lobes; an **inferior surface,** including the right, left, caudate, spigelian, and quadrate lobes;

FIG. 109



The liver. Posterior and inferior surfaces. (Drawn from His' models.)

anterior and posterior surfaces comprising the right and left lobes; a **lateral surface** of the right lobe, only.

It has an **inferior border or margin** which is thin and sharp, and notched opposite the falciform ligament, for the round ligament (**umbilical notch**), and opposite the cartilage of the ninth rib by a second notch for the fundus of the gall-bladder.

The left extremity of the inferior margin of liver is thin and flattened from above downward.

The **ligaments** of the liver are all peritoneal folds, except the round ligament, which is a fetal remnant of the umbilical vein. The ligaments hold the liver in position, and are as follows:

Falciform or suspensory.	Left lateral.
Coronary.	Round.
Right lateral.	

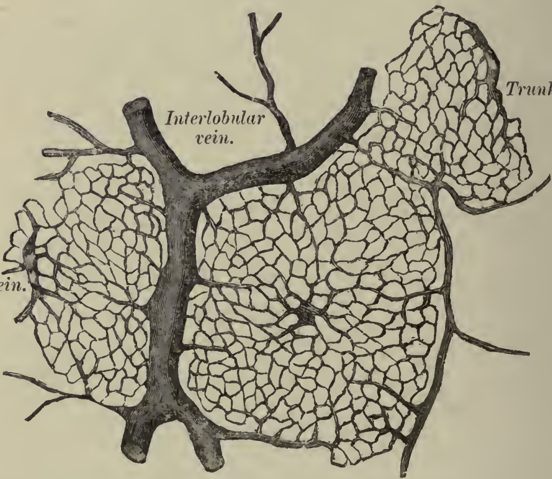
The **lobes of the liver** are also five in number. The *right* is the largest, being six times as large as the left. The *left lobe* is flattened, lies in the epigastrium, and is in relation below with the stomach. The *lobus quadratus* is on the under surface of the right lobe. The *Spigelian lobe* lies behind and above the preceding. The *caudate lobe,* or *tuberculum caudatum,* runs outward from the base of the Spigelian lobe to the under surface of the right lobe.

The **fissures of the liver** are five. The *longitudinal* separates the right and left lobes. The *fissure of the ductus venosus* is the part of the longitudinal fissure behind the transverse. The *transverse* is the point of exit (hepatic ducts) and entrance of the portal vein, hepatic arteries, nerves, and lymphatic vessels. The fissure for the gall-bladder is on the under surface of the right lobe, parallel to the longitudinal fissure, separated from it by the quadrate lobe. The *fissure for the inferior vena cava,* sometimes a complete canal, lies to the right of the Spigelian lobule.

The Structure of the Liver.—It is covered by a serous layer derived from the peritoneum, except the posterior

surface, which is in relation with the diaphragm for about 3 inches, included between the reflections of the coronary ligaments. Beneath this serous covering is a fibrous or areolar capsule (**capsule of Glisson**), which passes into the transverse fissure around the vessels and blends with the areolar tissue which holds the liver lobules together.

Fig. 110



Horizontal section of injected liver (dog).

The lobules compose the main mass of the liver substance, and consist of irregular chains of hepatic cells, which secrete the bile, and are surrounded by a capillary net-work of intralobular veins, which are the minute terminations of the portal vein; they course toward the centre of the lobule, opening into a central intralobular vein; also small arteries, branches of the hepatic artery, lie between the cells.

In addition, within the chain of cells are the minute biliary ducts, or capillaries, which are the commencement of the hepatic duct that conveys the bile formed

by the liver cells to the intestinal canal and gall-bladder.

The Functions of the Liver.—(1) The liver secretes the bile; (2) produces and stores glycogen until needed to aid in the nutrition of the tissues; (3) aids in the formation and excretion of urea. The production of bile and its physiologic actions have been described. (See Part Played by the Bile in Digestion, page 281.)

The Formation and Function of Glycogen.—Glycogen is derived from the dextrose resulting from the action of the intestinal juices upon the food. It represents the products of the carbohydrates absorbed as dextrose and carried in the blood by the branches of the portal vein to the liver, when it undergoes chemical changes, due to the action of the liver cells, and is deposited as a non-diffusible body. Glycogen is stored in the liver until needed by the body tissues.

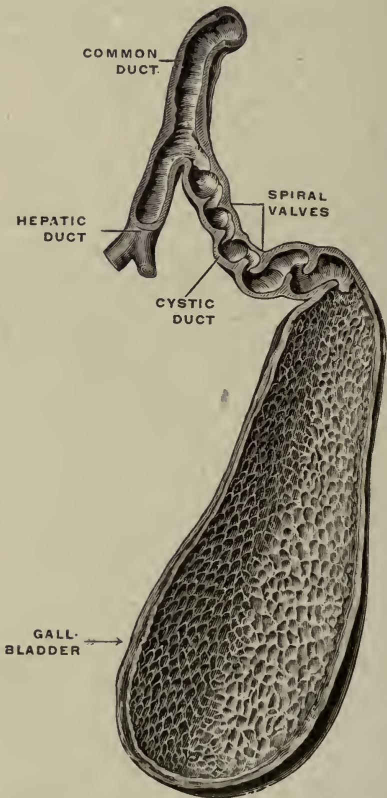
The Formation of Urea.—Urea is believed to be produced and excreted by the liver cells. It is formed from ammonium salts, as carbonate, lactates, which are formed as a result of tissue metabolism upon the proteins contained in the food we eat, and these salts are absorbed from the tissues or from the intestines, and conveyed by the blood to the liver cells, where they are converted into urea and eliminated as a waste product. It is excreted by the kidneys and found in the urine.

The Gall-bladder.—This is a pear-shaped sac lying in the impression of the right lobe of the liver. It is the reservoir for the bile. It is 4 inches long and $1\frac{1}{2}$ inches broad, holding 8 to 12 drams, and is held in place by areolar tissue and the peritoneum. Its **relations** are as follows: Above, liver; below, ascending duodenum, pyloric end of stomach, hepatic flexure of colon; in front, abdominal wall (ninth or tenth costal cartilages).

The *hepatic duct* is formed by the junction at an obtuse angle of a branch from each lobe of the

liver and runs downward and to the right for nearly 2 inches and joins the cystic duct to form the common bile duct. The *cystic duct* of the gall-bladder is $1\frac{1}{2}$ inches

Fig. 111

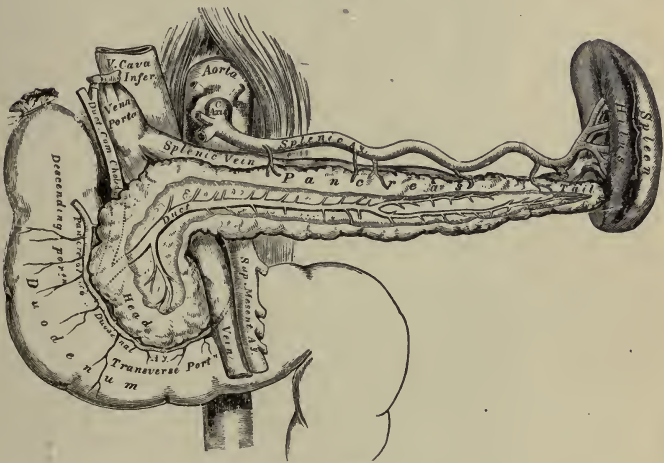


The gall-bladder and bile ducts, opened up. (Spalteholz.)

long, and descends toward the left and joins the above as described. The *common bile duct* is nearly 3 inches long and 3 lines in diameter. It runs along the right border of the lesser omentum, behind the first part

of the duodenum, and between the pancreas and descending duodenum, then to the right of the pancreatic duct, with which it communicates by a common orifice, at the summit of a papilla situated just below the middle of the inner wall of the second portion of the duodenum. The cystic artery and veins comprise the blood-supply of the gall-bladder and its duct.

Fig. 112



The pancreas and its relations. (Gray.)

The Pancreas.—**The pancreas** is a compound racemose gland, of a pinkish-white color. Situated at the back of the epigastrium and left hypochondrium; connected to the posterior abdominal wall by connected tissue, and lies posterior to the stomach and behind the peritoneum. It is 5 or 6 inches long; its breadth is $1\frac{1}{2}$ inches; its thickness $\frac{1}{2}$ to 1 inch, being greater at its right extremity and upper border. The pancreas is divided into a **head**, a **neck**, a **body**, and a **tail**.

The duct of the pancreas is called the **pancreatic duct or canal of Wirsung.** It extends transversely

through the substance of the gland to drain the lobules by means of small ducts which open into it. Increasing in size it reaches the neck, passes downward, backward, and obliquely to the right, piercing the muscular and mucous coat of the second portion of the duodenum where it opens into the **ampulla of Vater**, common to it and the **bile duct**; the latter opens into the canal of the duodenum.

The Structure of the Pancreas.—It is similar in structure to the salivary glands, consisting of numbers of lobules, forming lobes, and all held together by connective tissue. Each lobule contains one of the branches of the main duct, which terminates in the grape-like alveoli. The alveoli are lined by cylindric cells, which differ in their appearance. They are divided into a central set, in the end of the alveoli, which are dark and granular, and a peripheral set, in the outside of the former, which are clear. During digestion the granular area becomes broader and the cells show an increase in granules; in the interval of rest following active digestion the clear zone increases in width, showing an absence of granules.

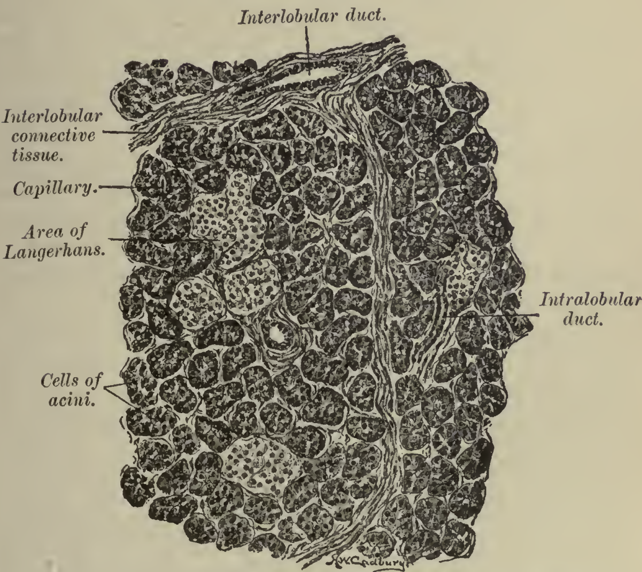
The Areas or Islands of Langerhans are groups of globular cells arranged in columns situated between the alveoli; surrounded by connective tissue, which separates them from the alveoli and each other. The connective tissue contains large, twisted, capillary bloodvessels. These groups of goblet cells are supposed to secrete an internal secretion, which is absorbed by the blood and carried to the different tissues. Metabolism of the carbohydrates is interfered with, if any diseased condition or removal of the pancreas takes place. The secretion from the cells of the alveoli, on the other hand, secretes the pancreatic juice.

The pancreatic secretion[1] leaves the pancreas by way of the duct of Wirsung; it is supposed to create

[1] See page 279 for action of pancreatic secretion during digestion.

an internal secretion which regulates the production of glycogen by the liver, thus possessing both an internal and external secretory function.

FIG. 113



Section of human pancreas, showing pancreatic islands. (Radasch.)

Ductless Glands.—The ductless glands of the body are:

Thyroid.	Thymus.
Parathyroids.	Suprarenal capsules.
Spleen.	Pituitary body.
Carotid.	Coccygeal.

The above glands aid in the nutrition of the whole body as well as in that of individual organs by means of an **internal secretion** which is absorbed by the blood and lymph streams. This material, derived from the

circulation, is changed within the gland by some unknown phenomena and secreted by the cells of the ductless glands to be taken into the blood and lymph direct, and thus aid in promoting the metabolism of the body. They possess no ducts.

The Thyroid Gland.—This is a very vascular organ, situated at the front of the neck, overhanging the upper rings of the trachea and laterally extending as high as the oblique line on the alæ of the thyroid cartilage, and as low as 1 inch above the upper border of the sternum, when the head is extended. It weighs about 1 ounce; slightly heavier in the female. It has three lobes—**two lateral** connected by an **isthmus**; and one **third** or **middle lobe.** It is firmly attached to the cricoid cartilage and posterior fascia of the trachea by two **lateral** or **suspensory ligaments** and its lobes and isthmus are enclosed within a fibrous capsule derived from the pretracheal portion of the **deep fascia** of the neck.

The **isthmus** lies on the second and third ring of the trachea, and measures about $\frac{1}{2}$ inch in breadth and depth.

The **functions** of the thyroid are not thoroughly understood. It is an established fact, however, that when the gland is secreting more or less than the normal quantity, changes in development arise as a result of some physiologic disturbance interfering with the general metabolism of the body; as **cretinism,** a condition occurring in infants and children as a result of a congenital absence or arrested development of the gland; **myxedema,** a condition (occurring in adults) of the skin in which it becomes thickened, giving rise to a change in the patient's expression, due to the face becoming broader, swollen, and flattened. The mind is dull, the subject is almost idiotic as regards the mental condition. Myxedema is due to atrophy or some pathologic change taking place in the gland which interfered with its normal secretion; removal of the

gland by operation gives rise to a similar condition, called **cachexia strumipriva**; an increase in the secretion from the thyroid gland causes a condition characterized by protrusion of the eye-balls—the patient's expression is staring and frightened—palpitation of the heart and enlargement of the gland, termed **exophthalmic goitre** or Graves' disease. An enlargement of the thyroid gland, which is gradually progressive, can be seen in the necks of people living in or coming from certain localities where the diseased condition is due to the drinking water containing lime; this is termed ordinary goitre.

The Parathyroid Glands.—These are small, reddish-brown bodies, composed of masses of cells, arranged in a more or less reticular manner with numerous intervening bloodvessels. They are usually found one on either side (the superior) at the level of the lower border of the cricoid cartilage, behind the junction of the pharynx and esophagus, and in front of the prevertebral fascia. The lower are just below the lower edge of the lateral lobe one on either side. There are usually four, but may be only three, or again, as many as six or eight. Their location is variable.

The functions of the parathyroids have not been sufficiently established to warrant a description within these pages. However, their removal from animals has given rise to **tetany**, characterized by spasmodic contractions and paralyses of certain groups of muscles, convulsive seizures, and death.

Spleen.—The spleen is the largest of the ductless glands. It is found in the left hypochondrium, entirely surrounded by peritoneum, except around the hilum, which attaches it to the fundus of the stomach (the gastrosplenic omentum). It is purplish in color, oblong, flattened, tetrahedral form, soft, of a very friable consistency, and highly vascular. It measures 5 inches in length, 2 to 3 inches in width, and 1 to $1\frac{1}{4}$ inches in thickness at the centre. It weighs $6\frac{1}{2}$ ounces,

The spleen is attached to the stomach by the **gastrosplenic** omentum. The **lienorenal** ligament is a peritoneal fold, which attaches it to the upper pole of the left kidney, and the **phrenocolic** assists to support it by its attachment to the diaphragm.

The spleen when seen under the microscope shows a capsule of fibrous tissue which sends off slips or trabeculæ from its under surface; these spread out and form a connective-tissue supporting frame-work for the contents of the organ, which consists of a dark red semifluid mass called the splenic pulp, filling the spaces between the fibrous tissue. Microscopically the splenic pulp is seen to consist of adenoid tissue, rich in leukocytes or white-blood cells, arranged in small groups throughout the pulp, called **Malpighian corpuscles**; red corpuscles are also present in the pulp.

The Functions of the Spleen.—Owing to the numbers of red cells seen in the splenic pulp undergoing all stages of disintegration, it has been concluded that the spleen aids in the destruction of red cells; another theory is based on the presence of the large quantity of white cells within the Malpighian corpuscles, that the spleen is the chief centre for the production of white cells, and thus contributes to the formation of the blood.

The spleen is larger in childhood than old age; it is enlarged during and after digestion. In typhoid fever and malaria a marked increase can be noted; also in various blood diseases.

Thymus Gland.—The thymus gland is a temporary organ, attaining its full size at the end of the second year and gradually shrinking until puberty, when it entirely disappears. Consists of two lateral lobes placed in close contact along the median line. It is found in the superior mediastinum, covered by the sternum and the origins of the sternohyoid and sterno-thyroid muscles; below, it rests upon the pericardium, and separated from the arch of the aorta and great

vessels by fascia. In the neck it lies on the front and sides of the trachea beneath the sternohyoid sternothyroid muscles.

Suprarenal Glands.—The **suprarenal glands** are two flattened bodies, of a yellowish color, found in the epigastrium, lying behind the peritoneum, and above and in front of the upper extremity of each kidney. They are triangular in shape, $1\frac{1}{2}$ to nearly 2 inches in length, less in width, and $\frac{1}{4}$ of an inch in thickness.

The Functions of the Suprarenal Glands.—They secrete a substance, termed adrenalin (takamine, Aldrich) or epinephrin (Abel), which is absorbed by the blood, and stimulates to increased activity the muscle fibers of the heart and arteries, and thus aids in maintaining the normal blood-pressure. Disease of the suprarenal glands causes a bronzing of the skin and mucous membranes with disturbances of nutrition, muscular weakness, and anemia. Gradually the heart becomes weak; the pulse is soft and feeble, indicating a general reduction in blood-pressure from interference with the secretion of the active physiologic material from the cells of the gland. Addison's disease is the name applied to this condition, as he first described the disease.

The Pituitary Body (Hypophysis).—The pituitary body is a small glandular body situated at the base of the brain, lodged in the sella turcica of the sphenoid bone. It is divided into an anterior and posterior lobe; the former is reddish in color, is larger than the posterior lobe, and is derived from an invagination of the epiblast of the mouth cavity, and shows microscopically gland tissue; the posterior lobe is yellowish gray in color, and represents an outgrowth from the brain. It is connected by a thin slip to the infundibulum.

The **functions** of the pituitary are still under investigation; however, it has been proved by experiment that an injection of the extract made from the internal

secretion of this gland will cause an increase in the force of the heart-beat and a rise in blood-pressure by stimulating the arterioles. According to Howell, the extract given intravenously from the posterior lobe will cause a rise in blood-pressure and slow the heart-beat, the extract from the anterior lobe being negative as to its effect on the circulatory and respiratory organs. Disease of the pituitary body will give rise to the condition of acromegalia, in which there is a marked enlargement of the bones of the face and extremities. When diseased in early life it is responsible for the progressive changes, characterized by extreme growth of the body, termed **gigantism**; also a marked increase of fatty tissue.

Carotid Glands.—The carotid glands or bodies are small reddish-brown bodies, oval in shape, their long diameter measuring $\frac{1}{5}$ of an inch. They are found in the cervical region, at the bifurcation of the common carotid artery into the internal and external carotid trunks.

Coccygeal Gland.—The coccygeal gland or body, or Luschka's gland, is as large as a millet-seed, found at the tip of the coccyx. It is connected with middle sacral artery.

QUESTIONS

1. Give the difference between an external and internal secretion.
2. Name some of the external secretions.
3. How are secretions utilized by the tissues of the body?
4. Name the secreting membranes of the body.
5. Name the organs of internal secretion.
6. Give the general arrangement of the structures seen in a secretory gland.
7. By what structure does a secreting gland communicate with a membrane upon which its secretion is poured out?
8. What part does the nerve system play in regard to gland secretion?
9. What is excretion?
10. Describe the structure of a mammary gland.
11. Is human milk alkaline or acid in reaction?
12. Does milk contain oil globules?

13. How much milk is secreted every day by the mammary glands in a healthy woman?
14. Give the chemical composition of milk.
15. How does woman's milk differ from cows' milk?
16. What is colostrum? Give its function.
17. Which is the largest gland of the body?
18. How much does the liver weigh?
19. How many lobes has it?
20. What structures pass out of and enter the transverse fissure of the liver?
21. Give the location of the liver in the abdominal cavity.
22. What is the serous membrane surrounding the liver called? The fibrous capsule?
23. What microscopic structures are seen in the liver lobules?
24. Name the functions of the liver.
25. How is glycogen formed? Where is it stored in the body chiefly?
26. Is urea a waste product resulting from metabolism? Which organs excrete it?
27. What is the function of the gall-bladder? Name its duct.
28. Where is it located?
29. What ducts form the common bile duct?
30. Where does the common bile duct drain?
31. How long is the cystic duct? The common bile duct?
32. To which variety of glands does the pancreas belong?
33. Give the dimensions of the pancreas.
34. Name the duct of the pancreas. Which portion of the duodenum does it open into?
35. What is the opening in the duodenum for the common bile and pancreatic duct called?
36. How does the pancreatic secretion leave the pancreas?
37. Name the organs of internal secretion.
38. Which one of the ductless glands is the largest?
39. Give its dimensions and weight.
40 How is the spleen attached to the stomach? The left kidney? The diaphragm?
41. Where are the suprarenal glands located in the abdominal cavity?
42. Name their functions?

CHAPTER XV

THE FACTORS ESSENTIAL TO THE PRODUCTION OF BODY TEMPERATURE OR HEAT

THE human body maintains an even temperature during life, due to the results of chemic changes going on within the tissues and organs of the body as a result of metabolism. These changes result from the processes of oxidation taking place in the cells of the body by the union of oxygen with the elements carbon and hydrogen, contained within the food we eat, either before or after they become constituents of the tissues. During metabolism of the body the food is again broken up into simple compounds, as carbon dioxide, water, and urea, which evolve a large portion of their energy as heat and mechanic activity.

The body is continually giving off heat called heat dissipation, and this heat dissipation must be replaced by an equal amount of heat liberation, called heat production, by the tissues as a result of metabolism, else the even temperature of the body would not be maintained, as is necessary for the normal action of the physiologic processes of the body.

Heat Production.—Heat production is derived from the formation of carbon dioxide, urea, and water, as a result of oxidation of the tissues by the union of oxygen with the carbon and hydrogen of the food. And mechanically each of the following actions contribute to the production of heat: Contraction of muscles, during the secretions of glands, the force exhibited by the nerve system in producing its functions of receiving and conveying impulses throughout

the body to accomplish the various actions essential to the life of the individual.

Heat Dissipation.—Heat is given off by warming the food and liquids consumed, to the temperature of the body; in warming the air we breathe to the body temperature; in the evaporation of water from the lungs and skin; in the skin it is given off by the processes of radiation and conduction.

The quantity of heat essential to the maintenance of the body temperature and the quantity liberated is determined experimentally by a study of the heat values of different foods; another method is by means of an apparatus called a colorimeter, in which is collected and measured the heat given off as a result of oxidation of the food within and given off from the body daily.

Heat Values of Food.—By the first method 1 gram of food is burned, the hydrogen and carbon of the food is chemically converted into carbon dioxide and water as a result of oxidation, and during this change heat is given off and collected which the experiment has proved will raise the temperature of a given amount (1 kilogram) of water. The amount of heat evolved is expressed in gram or kilogram, degrees or calories.

A **calorie** is the amount of heat necessary to raise 1 gram of water 1° C. It has been demonstrated that certain foods produce far more heat than others (expressed in calories), and hence more or less heat will be dissipated, and an increase or decrease in energy will be apparent, dependent upon whether the diet is rich in proteins, carbohydrates, or fats. The carbohydrates and fats are reduced, after being absorbed to carbon dioxide and water, the proteins are changed to a compound—urea—with the liberation of heat, expressed in calories as follows:

1 gram of protein	4.1 calories
1 gram of fat	9.3 calories
1 gram of carbohydrates	4.1 calories

Knowing the above, it is easy to determine the heat units or calories each quantity of contained proteins, fats, and carbohydrates in a diet will liberate. The number of grams of protein are multiplied by 4.1 calories, which one gram of protein evolves; the number of grams of fat, by 9.3 calories, that one gram of fat evolves; and the number of grams of carbohydrates by 4.1 calories, the amount of calories that 1 gram of carbohydrates liberates. See example:

The quantity of protein consumed daily is 100 gm. = 100 × 4.10 or	410 calories
The quantity of carbohydrates consumed daily is 500 gm. = 500 × 4.1 or . . .	2050 calories
The quantity of fats consumed daily is 50 gm. = 50 × 9.3 or	465 calories
	2925 calories

The average number of calories required by an individual daily, to maintain an even temperature, and promote the normal energy of the body, is about 3000. Thus the heat dissipated by the body will nearly equal the physiologic heat values of the foods we eat.

The Temperature of the Body.—The equalization of the heat-dissipation and heat-production keeps the body at a standard temperature. This in olden times was taken by physicians simply by laying the hand on the skin. The introduction of the clinical thermometer has allowed of a more accurate and scientific means of reading the temperature. The temperature of the body varies in different locations, due to the chemic changes resulting from body metabolism varying in their intensity and extent in different parts of the body. This variation would be more marked were it not due to the fact that the blood and lymph absorbing the heat, evenly distribute it to all parts of the body, so that the change in temperature amounts to only a few degrees.

The normal body temperature in the axilla is 98.6° F. or 37° C. (French). This may be as low as 97.5° to 98° F. in the early morning, and reaching to 99° to 99.3° F. in the evening, and denote no abnormal condition of health; by mouth, 98.6° F. or 37° C.; rectum, 100.4° F. or 38° C.; vagina, 100.9° F. or 38.3° C. In infancy under six years of age, 99.4° F. or 37.4° C.; in the aged (sixty to eighty years), 98.2° F. or 36.8° C.

QUESTIONS

1. How does oxidation of the tissues effect heat production?
2. What mechanical actions of the body aid in heat production?
3. How is heat dissipation brought about?
4. What must occur in the tissues to equal heat dissipation in order to maintain an even body temperature?
5. How are heat values expressed?
6. How many calories will 1 gram of protein produce? 1 gram of fat? 1 gram of carbohydrates?
7. What is a calorie.
8. What is the average number of calories required to maintain an even temperature and promote the normal energy of the body?
9. What relation should the heat dissipated by the body bear to the heat values of the foods we consume?
10. Give the normal temperature when taken by mouth, axilla, and rectum.

CHAPTER XVI

THE ANATOMY AND PHYSIOLOGY OF THE URINARY APPARATUS (ORGANS); THE SKIN AND ITS APPENDAGES

THE URINARY ORGANS

THE urinary organs include the **kidneys,** which secrete or excrete the urine; the **ureters** convey it to the **bladder,** where it is retained until voided (micturition); then the **urethra** which discharges it from the body.

The Kidneys (Renes).—The **kidneys** are situated in the abdominal cavity on each side of the vertebral column, resting on the psoas magnus and the quadratus lumborum muscles. They are behind the peritoneum and correspond to the space included between the upper level of the twelfth thoracic above, and opposite the third lumbar vertebra below. The right kidney is lower than the left. In the female they are a little lower than in the male.

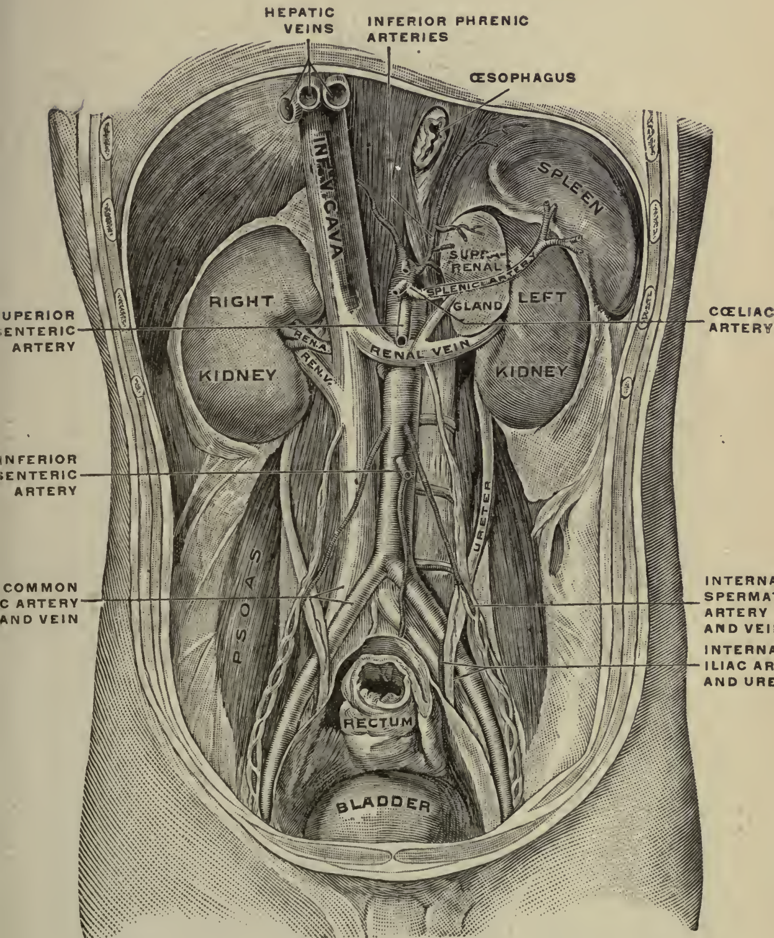
Each is bean-shaped, measures about 4 to 4½ inches in length, 2½ in breadth, and 1 to 1½ inches in thickness, and weighs about 4 to 6 ounces. They lie in the right and left hypochondrium, the epigastrium, and the right and left lumbar regions.

Fixation of the Kidney.—The kidney is embedded in a mass of fatty tissue (**capsule adiposa**) surrounded by a fibrous sheath named the **fascia renalis** continuous with the subperitoneal fascia.

The Structure of the Kidney.—The kidney is made up of a series of tubules supported by a frame-work of connective tissue, and surrounded by small capil-

laries, lymphatics, and nerves. On examining the incised kidney its surface presents an inner two-thirds,

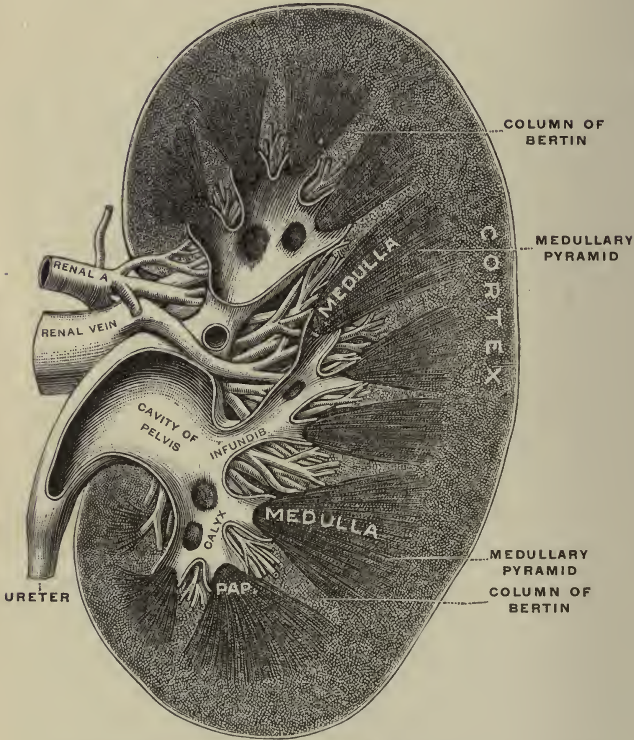
Fig. 114



Posterior abdominal wall, after removal of the peritoneum, showing kidneys, suprarenal capsules, and great vessels. (Corning.)

called the medulla, measuring $\frac{2}{3}$ to $\frac{3}{4}$ of an inch in thickness; and an outer one-third called the cortex, measuring $\frac{1}{3}$ to $\frac{1}{2}$ inch in thickness.

Fig. 115



Vertical section of kidney, showing the secreting portion, the vessels, and the beginnings of the ureter. (Testut.)

The Medulla.—This consists of small pyramids, ten to twenty in number. The base of each is directed toward the cortex and the apices point toward the pelvis of the ureter, where they project into the calices of the same; each calix receives one,

two, or three papillæ. Each papillæ has a number of minute openings upon its apex for the excretory ducts of the pyramids; the latter pour the urine into the pelvis of the ureter. These orifices open into tubules and are practically the external outlet of the uriniferous tubules. They pass toward the base of the pyramid, and within this region are known as the tubes of Bellini. Continuing they enter the cortex, where they become enlarged and twisted, and follow an extremely tortuous course to turn backward into the medullary portion for some space, and are called in this position the **ascending limb of the loop of Henle**; they curve upon themselves again, and, while still within the medullary portion, are known as the **descending limb of the loop of Henle**; reënter the cortex, expand again, and becoming twisted (convoluted tubule), end in an ovoid enlargement termed **Bowman's capsule**, in which is a small collection of bloodvessels—the **glomerulus**, or **Malpighian tuft.** The capsule and contained bloodvessels, the glomerulus, constitute the small reddish bodies called **renal** or **Malpighian corpuscles**, which are scattered throughout the cortex of the kidney.

The Cortex.—This is reddish brown in appearance, and lies just beneath the capsule of the organ. It contains the Malpighian corpuscles. When examined with a lens it has a light colored, ray-like appearance. The lighter rays are termed the **medullary rays**, and are found by the collection of uriniferous tubules (loops of Henle) from the medullary portion. The darker colored intervening substance is called the **labyrinth**, from its complexity of structure, and is composed of the Malpighian corpuscles and the various loops of the tubules.

The Uriniferous Tubules.—Microscopic examination of the kidney substance is the only method by which the uriniferous tubules can be seen and understood.

However, I will endeavor to make as clear as possible their course. The tubules practically start in the cortex as a capsule of Bowman, which surrounds the capillaries (glomerulus). The tubules run a very irregular and distorted course, and finally end in straight tubules which pass through the pyramids to empty into the calices of the pelvis of the ureter. Bowman's capsule is lined by flattened epithelial cells resting on a very delicate basement membrane. The convoluted portions of the tubules are lined with cuboidal epithelium and the loops of Henle contain more or less flattened epithelium.

The Ureters.—The **ureters** are two tubes, and convey the urine from the kidney to the bladder. The urine is collected from several **minor calices**, ten to twenty in number, which open into the **major calices**; the latter by their junction form the pelvis or dilated portion of the ureter. It is on a line with the first lumbar vertebra.

The *ureter* proper is divided into an **abdominal portion** (pars abdominalis) and a **pelvic portion** (pars pelvina). They are 10 to 12 inches in length and $\frac{1}{6}$ of an inch in diameter. The walls are from 1 to 2 mm. thick.

The Urinary Bladder (Vesica Urinaris).—The bladder is situated in the pelvic cavity, but in infancy and when distended in the adult, extends into the hypogastrium. It measures when moderately distended, 5 to 5½ inches in length, 4½ in width, and 3 inches from before backward. It holds a pint of urine without discomfort. The bladder presents a superior, antero-inferior, and two lateral surfaces; a base or fundus, and an apex or summit.

The **interior of the bladder** shows the mucous membrane thrown into **rugæ**, the **orifices** of the **ureters**, and the **trigone**, also the orifice of the **urethra**, which empties the urine from the bladder. The ureteral orifices are

about 2 inches apart when the bladder is moderately distended. The **trigone** is a smooth, triangular surface, paler than the rest of the mucous membrane. It is bounded at the basal angles to the orifices of the ureters, and the apex to the internal urethral orifice. The **ureteral folds** are the prolongations extending beyond the ureteral orifices, of the transverse ureteral fold containing muscle fibers covered by the mucous membrane. The internal urethral openings is surrounded by a circular fold of mucous membrane, called the **annulus urethalis.**

The **ligaments** of the bladder are: **true and false.** The true are the two anterior, two lateral, and the urachus. The false are five, and consist of folds of peritoneum.

Method of Urine Secretion.—The urine contains the waste products resultant from body metabolism which are eliminated through the kidneys, ureter, bladder, and urethra.

Several theories have been demonstrated in regard to how these waste products pass from the blood to the urine. However, the two accepted methods of urine secretion or excretion are based on the principles of filtration and secretion.

The uriniferous tubules as described above commence as the capsule of Bowman, which surrounds a collection of capillaries (glomerulus). Bowman's capsule is simply an indentation of the tubule. It consists of two walls, an outer one covered with flattened epithelium resting on a very thin basement membrane, and an inner wall consisting of flattened epithelium which is reflected over and encloses the glomerulus. Thus the blood in the capillaries is separated from the interior of Bowman's capsule by the intervention of the capillary wall and the inner layer of epithelium, lining the inner wall of the capsule. The secretion of urine primarily takes

place by a rise of blood pressure in the arterioles (afferent vessels). The capsule of Bowman becomes so distended that the two layers of cells approximate and practically obliterate the cavity between them. Then the water, salts, sugars, peptones, etc., pass from the blood to the interior of the capsule of Bowman, by a process of filtration or transudation through the capillary wall and the thin inner layer of Bowman's capsule, and pass along the tubules. However, Heidenhain believes that the latter constituents of the urine are passed through the glomerular epithelium by the processes of cell selection and cell activity; in other words, the entire constituents of the urine obtained in the capsule of Bowman from the blood is due to process of secretion, assisted or regulated by the degrees of blood-pressure, blood-velocity, etc.

The blood of the glomerulus being emptied of a portion of its water, salts, etc., as described above, still possesses other waste products in the blood which must be eliminated as urea, uric acid, etc. This further elimination is based on a distinct and proved function of the cells, lining the convoluted tubules of the kidney, of selecting from the blood and secreting the above-mentioned products as constituents of the urine. The methods by which these products leave the glomerulus and reach the cells of the convoluted tubules is as follows: A small arteriole leaves each glomerulus (efferent vessel) and divides and subdivides, forming a capillary net-work, which surrounds the convoluted tubules, thus bringing the blood in intimate relation with the lining cells of the tubules, which, to repeat, select and secrete the urea, uric acid, etc., from the blood, and eliminate them in the urine.

The remaining quantity of blood which has given off its waste product to be eliminated by the two methods described above, is taken up by venules which anastomose with the arterioles around the con-

voluted tubules and straight tubules, and is returned through the renal vein to the venous system.

The Urine.—The urine is the fluid by which the end-products resulting from tissue metabolism are excreted or, literally speaking, are secreted by the kidneys from the body. The phenomena, however, is essentially the same as takes place during secretion of fluids by the body cells. It must be remembered that to perform work, create energy, nourish, and develop the body from birth to death, food is necessary. The body receives its nourishment from the food we eat, and the essential constituents of the same are used by the tissues to perform the various and complex processes necessary to carry on and maintain the normal physiological functions of the human body. Were this intake of food not used or eliminated, there would be a general interference of the normal functions of cell life, but as we have demonstrated in previous chapters, it is used and then undergoes changes, the residue forming products which must be eliminated, and the urine is the fluid by means of which this occurs.

Normal urine is a pale yellow or amber-colored fluid, with an aromatic odor and acid reaction. Its **specific gravity** is 1.020, but varies between 1.015 to 1.025. It is usually transparent, except when mucus, phosphates, urates, render it cloudy in appearance.

The **color** varies from a pale yellow to a reddish brown, dependent upon the physiologic processes occurring prior to elimination. Its color is due to the presence of a pigment-urobilin, urochrome, uroerythrin, derived from the bile pigments absorbed from the liver or alimentary canal. The **acidity** of the urine is due to the presence of acid phosphates of sodium and calcium. Urine is usually acid in the morning, alkaline or neutral following digestion.

The **quantity of urine** passed in twenty-four hours amounts to 40 to 50 ounces ($2\frac{1}{2}$ to 3 pints 2 ounces).

The **odor** is due to the presence of aromatic compounds.

Composition of Urine:

Water	1500.00 c.c.
Total solids	72.00 gm.
Urea	33.18 gm.
Uric acid (urates)	0.55 gm.
Hippuric acid (hippurates)	0.45 gm
Kreatinin, xanthin, hypoxanthin, guanin, ammonium salts, pigments, etc.	11.21 gm.
Inorganic salts, sodium and potassium sulphates, phosphates, and chlorides; magnesium and calcium phosphates. Organic salts: lactates, acetates, formates in small amounts	27.00 gm.
Sugar	a trace.
Gases—nitrogen and carbonic acid.	

Urea, being the most abundant and important organic compound of the urine, will be described. It is present to the amount of 2 to 3 per cent. It is found after analysis of the urine to consist of a colorless, neutral substance, crystallizing in long, silky needles. It is composed of carbon, oxygen, nitrogen, and hydrogen (CON_2H_4). The daily quantity excreted amounts to 30 to 34 grams. It is the end-product of the protein metabolism which has gone on within the body, and the quantity excreted in the urine is dependent upon the amount of protein food consumed and upon the degree to which the protein constituents of the tissues have undergone metabolic changes.

THE SKIN

The skin is the structure investing the entire outer surface of the body, blending with the mucous membranes which bound the cavities leading into the body, as the mouth, etc. Its dimensions vary in thickness in different parts of the body, from $\frac{1}{8}$ to $\frac{1}{100}$

of an inch, total area 16 to 20 square feet in man, and 12 to 16 square feet in woman.

The skin secretes a clear, colorless fluid, the sweat; it acts as a protection to the underlying structures, and aids in the excretion of waste-products of metabolism, possessing an accessory function in conjunction with the lungs and kidneys of elimination of these products from the body. It also assists in regulating the temperature of the body by promoting heat dissipation.

The skin must be studied under the microscope in order to properly grasp its structure. There are two principal layers, superficial and deep; the former is termed the epidermis, the latter the derma or corium.

The Epidermis.—This consists of epithelial cells derived from the ectoderm. There are two layers within the epidermis: **superficial** or **horny layer,** and **deep** or **Malpighian layer.** The horny layer consists of non-nucleated scaly cells composed of keratin. The surface cells of this layer are being continually rubbed off, and are replaced by cells from the Malpighian layer underneath, which undergo a change and are converted into keratin as they approach the surface. The **Malpighian** or **deep layer** is divided into four layers, named from without inward—**stratum lucidum, stratum granulosum, stratum mucosum,** and the **stratum germinativum.** The stratum mucosum contains the prickle cells which contain the pigment granules that give to the skin its different individual and racial characteristics in regard to color.

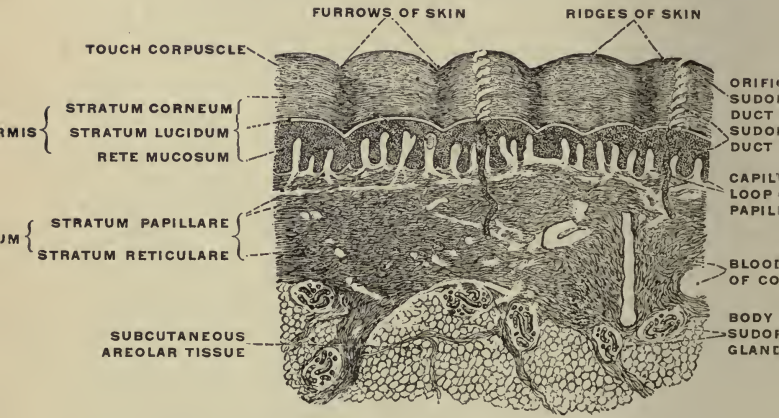
The Derma, Corium, or True Skin.—This is composed of the two layers: **superficial** or **papillary** layer, and the **reticular.**

The **superficial** or **papillary layer** lies beneath the epidermis. It contains numerous projections called papillæ, and is composed of a net-work of fine bundles of fibrous tissue. The papillæ are composed of fibrous

and elastic tissue. They project from the true skin or corium, and enter into depressions of the epidermis. The **reticular layer** connects the skin with the underlying structures. It also supports the minute blood-vessels, lymphatics, and nerves which are distributed to the papillæ.

The **subcutaneous tissue** is the layer beneath the reticular layer of the true skin, which holds the skin to the parts beneath. It is made up of thin connec-

Fig. 116



Vertical section through the skin of the finger tip. The layers of the epidermis and of the corium. The subcutaneous areolar tissue. The sudoriferous or sweat gland. (Toldt.)

tive tissue which crosses repeatedly and forms spaces. The skin in certain parts is held firmly to the underlying structures by the subcutaneous tissue, as the skin over the palms and soles of the feet; in others it is loosely attached and is freely movable, as the skin over the front of the arms and neck.

The skin is supplied by branches of the larger

arteries coursing through the subcutaneous tissues. These form minute capillary plexuses which send off branches to form other plexuses in the corium and papillary layer; from the latter branches pass to the papilla, sweat glands, sebaceous glands, fat, and hair follicles.

The Appendages of the Skin.—They are the **nails, hairs,** the **sudoriferous** or **sweat glands,** and **sebaceous glands.**

The Nails.—These are flattened, elastic structures of a horny texture, placed upon the back surface of each distal extremity of each finger and toe. The nail is implanted by means of a portion called the **root,** within a groove in the skin. The rest of the convex surface of the nail is called the **body.** Beneath the root and body is a portion of the cutis called the **matrix.** This is the part from which the nail grows. The white, crescentic-shaped area of the nail seen behind the matrix and above the root is called the **lunula.** Its color is due to its being less vascular compared to the remaining portion of the nail. The nail can be injured, and if any cells of the Malpighian layer remain, a new nail will develop from these cells.

The Hairs.—They are found in certain regions of the body. They act as a protection to the part; prevent friction; prevent foreign bodies from entering the organs they protect, as the eyes, nose, etc. We speak of hairs of the head, of the eyebrows, of the axilla, of the eyelids, of the nose, of the pubes, and of the skin. They vary much in length, thickness, and quality. In some individuals the hair is straight, in others curly. Hairs usually are oblique to the surface from which they arise.

Hairs are modifications of the skin (epidermis) and consist essentially of the same structure as it. Hair consists of the **root,** the part implanted in the skin;

the **shaft**, the portion extending from the surface; and the **point**.

The root of the hair presents at its deep extremity a bulb-like enlargement, the **hair-bulb**, which is lodged in a follicular involution of the epidermis called the **hair follicle**. The hair follicle commences in the surface of the skin with a funnel-shaped opening, and passes inward in an oblique direction, to become dilated at its deep extremity or fundus, where it corresponds with the bulbous shape of the hair which it contains. Each hair follicle has at its base a small, conical, vascular eminence or papilla, the hair papilla, similar to the papillæ found upon the surface of the skin. The latter are highly vascular and probably supplied with nerve fibrils. Each hair follicle has an opening into it near its free extremity, the openings or orifices of the ducts of one or more sebaceous glands. Connected with the hair follicles are minute bundles of involuntary muscle fibers called **arrectores pilorum**. They originate from the superficial surface of the true skin, or corium, and are inserted into the outer surface of the hair follicle, below the orifice of the duct of the sebaceous gland. They are located on the side toward which the hair slopes, and when they contract elevate the hair.

The Sebaceous Glands.—These are simple and compound racemose glands which open into the hair follicle, and sometimes the skin surface, by means of a duct. These glands are lodged in the surface of the true skin or corium. They are very plentiful, and are found in all parts of the body, especially in the skin of the face and scalp; also numerous around the openings of the mouth, anus, nose, and external ear, but are not found in the skin covering the palms of the hands and the soles of the feet. Their structure consists of a delicate transparent membrane, enclosing epithelial cells.

Sebum is the oily fluid secreted by the sebaceous glands. It contains, by analysis, water, epithelium, proteins, fats, cholesterin, and inorganic salts.

The pouring-out of sebum by the glands is not a true secretion, but occurs as a result of multiplication and breaking down of the gland epithelium. Sebum when first secreted is oily and semiliquid, but soon becomes hard and acquires a cheese-like consistency. It lubricates the hair and skin and prevents dryness and roughness.

Vernix caseosa is the whitish, oily substance seen covering the body of the newborn child. It is supposed to keep the skin in a normal condition by protecting it from the effects of the long-continued action of the amniotic fluid in which the fetus is suspended during intra-uterine development.

The Sweat Glands.—The sweat glands are the glands which when active promote perspiration and aid in heat dissipation, at the same time eliminating waste products as the result of body metabolism, brought to them by the blood.

They are situated in the lower part of the corium, derma, or true skin, and sometimes in the subcutaneous tissue. The glands are tubular, and the lower or inner extremity is coiled upon itself a number of times, forming a rounded mass. Extending from this coil to the epidermis is the duct which follows a straight course in this situation, and after a few spiral turns, opens onto the surface of the skin. The glands consist of epithelial cells which rest upon a very thin basement membrane. These glands are very numerous; it has been estimated that they average from 2,000,000 to 2,500,000. They are more abundant in some localities than others. Each sweat gland is richly supplied with bloodvessels and nerves (vasomotor and secretor).

Perspiration.—Perspiration or sweat is the fluid secreted by the sweat glands of the skin. It is a

clear, colorless liquid of a specific gravity varying from 1.003 to 1.006; slightly acid in reaction and salty to the taste. Except when collected from the soles of the feet and palms of the hands, it is mixed with epithelial cells and sebum—secreted by the sebaceous glands. The amount of sweat secreted in twenty-four hours has been estimated at 700 to 1000 grams; however, this is uncertain, owing to the difficulty of collection, and the influence temperature, diet, drink, season of the year, etc., exert upon its secretion.

The secretion of sweat, though essentially an excretion, is chiefly concerned in the regulation of the body temperature in maintaining heat dissipation, rather than the elimination of waste materials by means of the sweat glands brought to them by the blood and lymph vessels.

The Part Played by the Nerve System on the Production of Sweat.—The secretion of sweat is practically the result of the activity of the epithelial cells of the sweat glands and is regulated by the nerve system. The fluid contained in the sweat is derived from the materials in the lymph channels, furnished by the blood.

To produce sweat there must be a glandular activity, and a regulation of the blood-supply. The former is brought about by a set of nerves called the **secretor**, which stimulate the cells to activity; the latter is regulated by nerves called the **vasomotor**, that regulate the blood-pressure of the capillaries and increase or decrease the blood-supply to the glands. Other influences increase the production of sweat, by their related nerve centres sending out impulses in two ways: first, by nerve impulses from the central dominating centre, supposed to be located in the medulla, being stimulated by mental emotions, as shock, shame, etc., venosity of the blood, hot drinks, violent muscular exercise, etc.; second, by reflex impulses being conveyed to the centres in the spinal cord by the sensor

nerves in the skin, as a result of hot applications, high external temperature, etc.

The nerve centres which regulate the secretion of sweat are located in the spinal cord and reach the glands of the skin by means of the sympathetic nerves with which the spinal nerves communicate. The dominating centre which is influenced to activity by emotional states, etc., is situated in the medulla oblongata and sends its impulses down the spinal cord and out through the spinal nerves and the sympathetic system to the cells of the glands. Sweat may be produced by a general relaxation of the bloodvessels which supply the sweat glands, resulting from a stimulation of the vasomotor nerves. But it must be remembered that a normal production of sweat is based on the activity of both the nerves influencing the blood supply to the glands, and the nerves which stimulate the cells of the sweat glands to secrete.

QUESTIONS

1. What organs include the urinary apparatus?
2. Give the location of the kidneys.
3. Which is higher, the right or left?
4. Give dimensions and weight.
5. Are the kidneys behind the peritoneum?
6. How are the kidneys held in position?
7. What do you understand by the medulla and cortex of the kidney substance?
8. How many pyramids are there in the medulla?
9. What part of the pyramids drain the urine into the pelvis of the ureter?
10. What structures form the medullary rays in the cortex of the kidney? The labyrinth?
11. What structures form Bowman's capsule? The glomerulus?
12. What structures form the renal or Malpighian corpuscles in the cortex?
13. Where do the uriniferous tubules commence in the substance of the kidney? Where do they terminate?
14. What type of epithelium lines Bowman's capsule? The convoluted portion of the uriniferous tubules? The loops of Henle?
15. How many ureters are there?
16. What is the function of the ureters? How long is each one?
17. Give the location, dimensions, and capacity of the bladder.

18. Name the portions of the bladder.
19. Through what structure does the urine leave the bladder?
20. Describe how the waste products of the blood pass through the capsule of Bowman during urine secretion.
21. What function do the cells of the uriniferous tubules play as regards the elimination of urea, uric acid, etc., from the blood-stream?
22. How does the venous blood from the capillaries of the kidney reach the venous system?
23. What resulting products of metabolism does the urine represent?
24. How much urine should be passed daily by a healthy individual?
25. What is the normal color of urine?
26. What end-product does urea represent in the urine?
27. Will a diet rich in protein increase the amount of urea?
28. What are the functions of the skin?
29. Name the two principal layers of the skin.
30. What is the function of the subcutaneous tissue?
31. Name the appendages of the skin.
32. Name the parts of a nail.
33. Name the functions of hairs.
34. Name the parts of a hair.
35. Describe a hair follicle.
36. What muscles cause hairs to stand erect?
37. Which layer of the skin lodges the sebaceous glands? When do they empty? In what portions of the body are they most abundant? Absent?
38. What is the secretion from the sebaceous glands called? Its function?
39. Describe vernix caseosa.
40. In which layer of the skin are the sweat glands located?
41. Do they possess ducts, and when do they pour out their secretion?
42. What are the functions of the sweat glands?
43. Is sweat acid or alkaline in reaction?
44. Does the secretion of sweat aid heat dissipation?
45. Name the nerves which stimulate the cells of the sweat glands to secrete, also regulate the blood-supply to a sweat gland.

CHAPTER XVII

ANATOMY AND PHYSIOLOGY OF THE NERVE SYSTEM

THE nerve system is divided for the purpose of description into the **cerebrospinal** and **sympathetic systems.** The cerebrospinal system consists of the **central nerve axis** (brain and spinal cord), and the **peripheral nerves** (cranial and spinal).

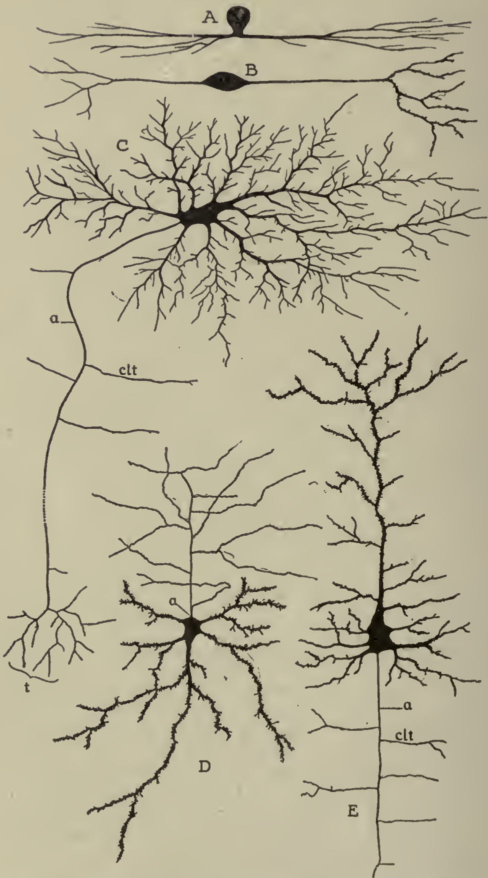
THE STRUCTURE OF THE NERVE SYSTEM

Neurone, or Nerve Cell Element.—The essential structure from which all the functions of the human body arise as a result of innervation, is the cell element called the **neurone.** They differ from all the other cells in the tissues, in that their protoplasm is extended in the form of processes, and these reach some distances from the nuclear portion of the cell.

The neurones are the essential structures concerned in all nerve reflex. However, the fact of a sensor impulse reaching a neurone from a muscle, gland, or other cell, does not say a motor impulse will be returned from the neurone direct, as the neurones are connected with other neurones by means of their extending processes, which have the power of reacting and sending out excitomotor impulses, and of checking or reducing the impulse to the structure to be innervated.

The neurones form an aggregation of cells which are the basis of the nerve system from which all

Fig. 117



Showing some varieties of cell bodies of neurones (diagrammatic). *A*. Unipolar (amacrine) cell from the retina. *B*. Bipolar cell from vestibular ganglion. *C*. Multipolar cell, with long axone, from spinal cord. *D*. "Golgi cell," with short axone breaking up into numerous terminal twigs. *E*. Pyramidal cell from cerebral cortex. *a*. Axone. *clt*. Collaterals. *t*. Telodendria.

nerve force originates, and which maintains the specific functions of the body expressed in motion, trophic changes, or stimuli of a chemic, mechanic (touch, sound), thermal, or photic nature.

Neurones are so arranged to be receptive and receive (afferent) impulses from other parts of the body. These are termed **sensor neurones.** Others are emissive and return (efferent) impulses; the latter are called **motor neurones**; if connected with muscle cells, **excitomotor**, and with gland cells, **excito-glandular.**

The neurones or nerve cells compose the cellular element of the whole nerve system, and the balance is the supporting white fibrous tissue and neuroglia derived from the supporting membrane or from the sheaths of vessels.

The Structure of a Neurone or Nerve Cell.—It consists of a cell mass or body containing a nucleus, and within the latter a nucleolus. From this cell body are given off protoplasmic processes of two different varieties: (1) **dendrites**, and (2) **axone**, or **axis-cylinder.**

The Bodies of Nerve Cells.—They vary in size, they measure 4 to 135 microns or more in diameter, and when it is considered that 1 micron is equal to $\frac{1}{25400}$ of an inch, their minute size may be appreciated. Neurones are classified according to the number of processes arising from the body, as **unipolar, bipolar,** and **multipolar.**

The Dendrites.—They are processes extending from the body of the cell in large numbers. They consist of the same structure as the cell, and thus increase the functional surface or expression of the cell. The dendrites never communicate with the branches of the same process direct, or anastomose with the terminals of dendrites from adjoining nerve cells. The function of the dendrites is supposed to be conductive and receptive for nerve impulses.

Small buds are seen at times along the course of dendrites. They are called **gemmules.**

Axone, or Axis-cylinder. — This arises from the body of the neurone, or nerve cell, as a cone-shaped process, and is seen as a very delicate fiber. In structure it differs from the dendrites. Each axone is uniform in diameter; and consists of fine fibrillæ, embedded in a clear protoplasmic substance (neuroplasm). Axones may be very short or as much as a meter in length. As a rule, only one axone is given off from a cell, and this form is termed **monaxic neurones**; however, more than one is present; as two axones, they are termed **diaxonic neurones**; and several axones, **polyaxonic neurones.**

Axones in certain portions of the nerve system (brain and spinal cord) possess fine branches called **collaterals**; they have the same structure as the axone from which they arise. Some axones, as Golgi cells, break up into branches after leaving the cell body, called **dendraxones.** The minute endings of the axis-cylinders and collaterals, which spread out like the branches of a tree, are termed **telodendria.**

The axone is the functional element of the nerve system which acts as the distributive or emissive conductor of nerve impulses.

Nerve Fibers.—Nerve fibers are simply continuations of the axis-cylinder or axone given off from the cell body of a neurone, with their surrounding investments, the myelin and neurilemma. They are classified into two varieties, according to whether or not the axis-cylinder possesses a medullary or myelin sheath, viz., **medullated** or **myelinic nerve fibers** and **non-medullated** or **amyelinic nerve fibers.**

Medullated Nerve-fibers.—These possess three distinct minute anatomical portions, when subjected to staining methods and examined under the microscope, namely: An external investing sheath, the neurilemma;

an intervening semifluid substance, the medulla or myelin; and an internal dark thread, the axis-cylinder or axone.

The **neurilemma** is a delicate, transparent membrane investing the myelin and axone, and occurs wherever the meylin sheath is absent. It possesses a nucleus, which may be seen between the nodes of Ranvier along the course of the nerve. It acts as a protective membrane to the nerve-fiber.

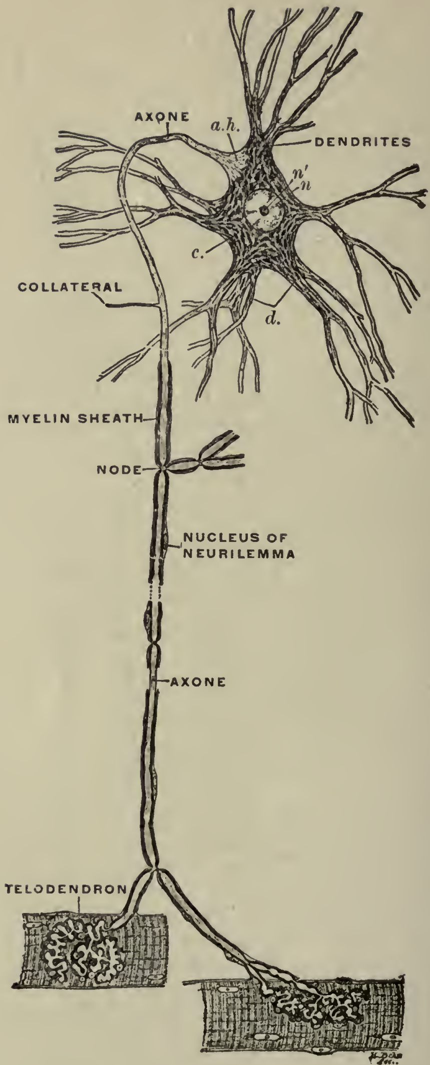
The **medulla, myelin,** or white substance of **Schwann** lies between the neurilemma and invests the axone. This is the substance of the nerve fiber, the presence of which imparts to the nerve tissue its white appearance, and gives rise to the term white fibers in speaking of nerve tissue, to differentiate them from gray fibers, the latter having no myelin sheath.

Along the course of nerve fibers may be seen a diminution or shrinkage in its caliber, due to an absence of the myelin sheath, permitting the neurilemma to be in direct opposition to the axis-cylinder. These narrowed parts are called the **nodes of Ranvier,** named after their discoverer. The portion of the nerve fiber between these interruptions is termed the **internodal** segment. Axones give off their collateral branches at the nodes of Ranvier.

Non-medullated or Amyelinic Nerve Fibers.—These are devoid of a myelin sheath, or the white substance of Schwann, thus presenting a gray appearance, and giving origin to the term gray fibers. Some non-medullated nerve fibers possess only an axis-cylinder, or axone. These are found in the central ganglia. Others possess a neurilemma investing the single axis-cylinder, and are the main variety of nerve fiber constituting the sympathetic system. Non-medullated nerve fibers are not so abundant throughout the nerve system as the medullated variety.

Nerves.—Nerves are round, flattened bundles of axones, held firmly together by investing connective

Fig. 118



Scheme of central motor neurone. (I type of Golgi.) The motor cell body, together with all its protoplasmic processes, its axis-cylinder process, collaterals, and end ramifications represent parts of a single cell or *neurone*. *a.h.*, axone-hillock devoid of Nissl bodies and showing fibrillation. *c*, cytoplasm showing Nissl bodies and lighter ground substance. *n'*, nucleolus. (Barker.)

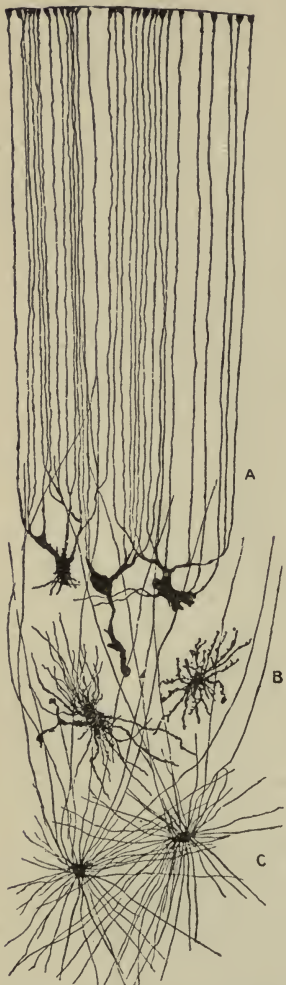
tissue. The latter contains the bloodvessels and lymphatics. Nerves are the connecting trunks which bring the brain and spinal cord in relation with the structures throughout the body—muscles, skin, glands, etc.

Structure of Nerves.—Examined under the microscope, each nerve shows on cross-section a collection of nerve fibers, or axones, arranged in bundles. The entire group being invested by a layer of connective tissue called the **epineurium**; however, each separate bundle of fibers within the nerve is enclosed in its own connective-tissue sheath — the **perineurium**, and the numbers of axis-cylinders, or axones, within the bundles are again enclosed in a delicate connective-tissue net-work called the **endoneurium**, or **sheath of Henle.**

Nerves as they pass from the brain or spinal cord are surrounded by the epineurium, and divide and subdivide as they give off branches to other nerves, and pass to their terminations. As each branch is given off the same sheath of connective tissue that enclosed the parent nerve accompanies it. This arrangement continues as the branches become smaller and smaller, until they reach their terminal point of distribution, where only a single nerve fiber remains, enclosed by a transparent membrane, the endoneurium or sheath of Henle. However, near the ultimate termination of a nerve the single nerve fiber may continue to give off branches, each one consisting of the axis-cylinder and myelin sheath.

The multitude of nerve cells or neurones entering into the formation of the nerve system are supported in a non-neural or inactive set of cells as regards nerve activity, called the supporting tissue elements of the nerve system. These consist of two kinds: (1) **neuroglia**, and (2) **connective-tissue trabeculæ** derived from the pia mater, or the bloodvessel channels. Neuroglia consist

Fig. 119



Neuralgia cells of brain shown by Golgi's method. *A*. Cell with branched processes. *B*. Spider-cell with unbranched processes. (After Andriezen.) (From Schäfer's *Essentials of Histology*.)

of cells—**glia cells** and **glia fibers**. There are two varieties of the latter—**ependymal cells** and **astrocytes.** The supporting tissue elements of the brain, etc., do not possess the power of developing or conveying nerve impulses; they are spoken of as non-neural.

The Origin of Nerves.—Efferent nerves, those which conduct impulses to the periphery, muscles, glands, bloodvessels, etc., in response to stimuli from the brain and spinal cord, originate in the nerve cells of the gray substance of these structures, and the axones are prolonged to form the nerve fibers. Nerves emerge from the brain and spinal cord as single rounded cords. They may possess only a single root of origin or two roots widely apart from each other, yet each of the two roots may be different in function, as seen in the spinal nerves, the anterior root being motor or efferent, the posterior sensor or afferent. The point at which a single nerve root leaves the brain or spinal cord is called the **superficial origin** of a nerve;

however, a tracing of the axones of these nerves for a distance into the gray substance of the brain or spinal cord, where they originate, will end in the nerve centre, which is termed the **deep origin** of a nerve.

Endings of Nerves.—It must be remembered that the course or appearance of a nerve has nothing to do with its function, for from all external or microscopic examination an efferent nerve cannot be differentiated from an afferent nerve. Nerves end in several ways, which vary in different situations.

The Efferent or Centrifugal Nerves.—This variety is motor and conveys nerve impulses away from the brain and spinal cord. Upon reaching their final ending, these lose both the neurilemma and myelin sheath. The axis-cylinder divides and gives off branches (collaterals) which join with other axones. These axis-cylinders come in direct contact with the tissue cells and are termed **end arborizations**, or **telodendria**, also end-organs, terminal organs, or end-tufts.

In muscles of the skeleton the axones of the nerves lose their neurilemma and myelin sheath; at the point they join the muscle fiber, and after giving off branches within the sarcolemma, appear to lie in a mass of sarcoplasm and nuclei which forms the **motor-plate**.

In the muscles of the viscera (involuntary) the nerve fibers are non-medullated, and belong to the sympathetic system or other neurones. The axones divide and subdivide to form plexuses which invest the muscle-cell bundles. Other branches are given off from the latter which finally come in intimate relation with each cell, upon the surface of which they are seen as granular masses.

In the glands the nerve fibers are derived from the sympathetic and other neurones; the axones reach

the acini of the glands, upon the outer surface of the acini; they form plexuses which pierce the acini wall, and give off minute branches to the gland cells.

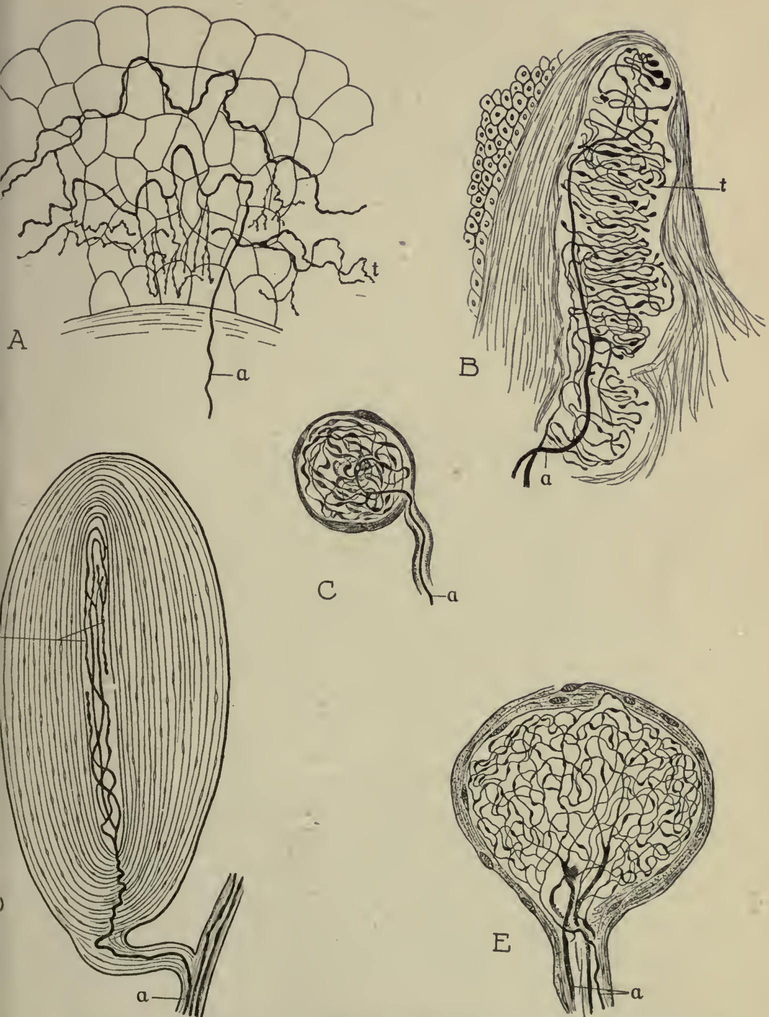
The Afferent or Centripetal Nerves.—These end as the former, but as this variety of nerve is sensor, and conveys sensations to the brain and spinal cord, the end-tufts are in intimate relation with specialized end-organs, which are essential to the appreciation of the complex sensations, viz., of sight, the retina in the eye; taste, the taste-buds in the tongue; smell, the olfactory cells in the nasal mucous membrane; hearing, the organ of Corti in the ear.

In the skin and mucous membranes the axones are in intimate contact with various end-organs which give rise to the numerous conscious sensations of touch, heat, thirst, hunger, and muscle sense, etc. The following are the chief names of the various end-organs:

1. Free endings in the skin.
2. Tactile cells of Merkel.
3. Tactile corpuscles in the papilla of the true skin.
4. Tactile corpuscles of Meissner.
5. Pacinian corpuscles found attached to the nerves of the hands, feet, intercostal nerves, and nerves in other situations.
6. End-buds of Krause in the conjunctiva, clitoris (female), penis (male), etc.

The Nerve Plexus.—It consists of a number of nerves communicating with other nerves, by means of collateral branches. Some plexuses are formed by direct branches being given off from the spinal cord, as the brachial, lumbar, sacral plexuses; others are formed by the terminal filaments of nerve fibers, as the plexuses in the skin, etc., still others may contain sympathetic nerve fibers derived from the sympathetic system, in addition to the sensor and motor nerves.

FIG. 120



Showing some varieties of peripheral terminations of afferent neurones (or "peripheral nerve beginnings"): *A*. Terminal fibrillæ in epithelium (after Retzius). *B*. Tactile corpuscle (Meissner's, after Dogiel). *C*. Bulboid corpuscle (Krause's, after Dogiel). *D*. Lamellated corpuscle (Pacini's, after Dogiel, Sala, and others). *E*. Genital nerve corpuscle from human glans penis (after Dogiel). *a*. Axone. *t*. Telodendria

In other words, the various nerve fibers, in forming a plexus, maintains the same function which the nerve possesses from its origin, as motor, sensor, or sympathetic.

Ganglia.—Aside from the arrangement of neurones or nerve cells in the cerebrospinal system, there is another collection of these neurones into small groups, connected with each other and the nerves of the brain and spinal cord called ganglia. Some ganglia are large enough to be seen by the naked eye, others are so small that they can scarcely be detected, unless examined by a lens or microscope. Ganglia compose the sympathetic system. They contain nerve cells with dendrites and axones, the greater number of the latter being non-medullated, and are surrounded by a connective-tissue capsule.

Ganglia are found on the dorsal or posterior root of the spinal cord, on the sensor root of the fifth nerve, on the facial and auditory nerves; and on the vagus and glossopharyngeal, along either side of the spinal column, where they form the gangliated cord of the sympathetic. Ganglia are receptive to impulses from nerves and other ganglia, and have the property of conducting impulses to other ganglia and nerves.

Classification of Nerves.—Nerves are pathways of communication between the brain and spinal cord, and the structures throughout the body which are dependent upon the nerve system for their development, growth, repair, and actions, and they require the stimuli from the brain to excite into physiologic activity the cells of muscles, glands, skin, mucous membranes, organs of the thorax, abdomen, etc.

There are two sets of nerves concerned in all nerve action or reflex. One which transmits impulses from the brain and spinal cord to the structure whose activities are to be increased or retarded; others

transmit impulses from the peripheral surfaces and organs of the body to the brain and spinal cord, which create conscious sensations or stimulate other reflex activity. The former are termed **efferent** or **centrifugal** (mostly motor nerves), the latter **afferent** or **centripetal** (mostly sensor nerves).

Physiology of Nerves.—Nerves possess the function of developing and conducting nerve impulses from the nerve centres in the brain and spinal cord to the periphery of the body, and at the same time to transmit nerve impulses from the periphery to the centres in the brain and spinal cord. As long as a nerve is capable of these qualities it is termed excitable or irritable, or possessed with irritability or excitability.

Nerve Stimuli.—Nerves must receive some form of external stimulation before they will develop or convey nerve impulses, as they do not possess the property of spontaneously developing and sending out nerve impulses. A stimulus to motor nerves (efferent), which excite it to activity, arise as a result of some molecular disturbance within the nerve cells, that acts upon the nerve fibers in connection with them. In the case of sensor nerves (afferent) the stimulus arises in the end-organs, which convey the nerve impulse to the sensor nerve fibers in connection with them.

Nerves react to stimulation according to their habitual function and distribution. If we stick our finger with a pin, the sensation of pain is felt, due to the fact that a sensor nerve has conveyed the nerve impulse, started in the end-organs in the skin, to the conscious centres in the brain; stimulation of the end-organs in rods and cones in the retina of the eye give rise to the sensation of light; stimulation of a motor nerve is followed by the contraction of a muscle which it innervates. Nerve function is supposed to

depend upon the peculiarities inherent in the central and peripheral end-organs, regardless of its construction and the character of the stimuli (Brubaker's *Physiology*).

Special Stimuli.—These comprise the group which act upon the nerves of special sense and give rise to conscious sensations, through the highly specialized end-organs, which transfer the nerve impulse to the filaments of the nerves in relation with them.

The afferent nerves (sensor) convey the impulse to the higher conscious centres, in response to the special stimuli, as follows: (1) Light or etheral vibrations act upon the end-organs of the optic nerve in the retina (sight and light); (2) sounds act upon the end-organs of the auditory nerve (hearing) in the ear; heat or vibrations of the air act upon the end-organs in the skin; (4) chemic agents act upon the end-organs of the olfactory (smell) and gustatory (taste) nerves of the nose and tongue respectively.

The efferent nerves (motor) convey impulses to the muscles, glands, etc., in response to stimuli which are supposed to arise as a result of a molecular disturbance in the central nerve cell, a combination of physical and chemic processes attended by the liberation of energy, which passes from molecule to molecule. The passage of the nerve impulse is accompanied by changes of electric tension.

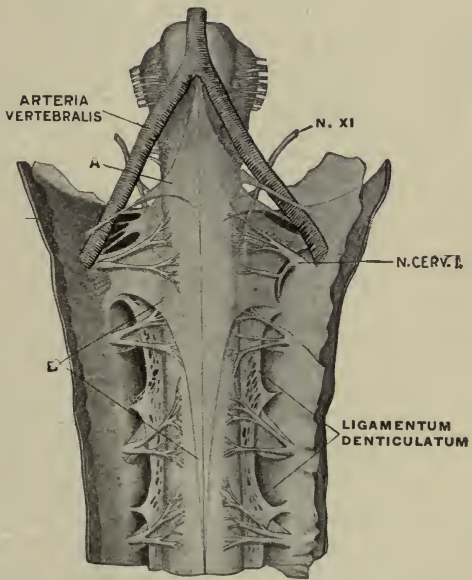
Thus, to sum up, all nerve impulses have their origin in the nerve cells or neurones, and these millions of associated neurones are the basis of all nerve activity. A theory has been created to simplify the understanding of nerve cell activity. It is called the **neurone theory of Waldeyer**, who explains it, based on the works of Golgi, Cajal, Forel, and others, as follows: (1) Each neurone is a distinct and separate entity; (2) the collaterals and other terminals of the neurones form no connections among themselves; (3) neurones are

associated, and impulses conveyed, by contact or **contiguity** of the axonic terminals of one axone with the cell body or dendrites of another neurone.

THE CENTRAL NERVE SYSTEM

The central nerve system or cerebrospinal axis consists of the (1) brain (encephalon) and its cranial nerves and associated ganglia; (2) the spinal cord and its spinal nerves and associated ganglia.

Fig. 121



Ventral view of medulla oblongata and upper part of spinal cord. Dura and arachnoid cut along median line and folded aside. *A* and *B* are fairly constant velar folds of the arachnoid. (After Key and Retzius.)

The Spinal Cord.—The spinal cord is the portion of the nerve system which is connected with the brain

above and the periphery of the body by thirty-one pairs of nerves. It is lodged in the spinal canal, ensheathed by the membranes, dura mater, arachnoid, and pia mater, and commences above at the atlas

Fig. 122

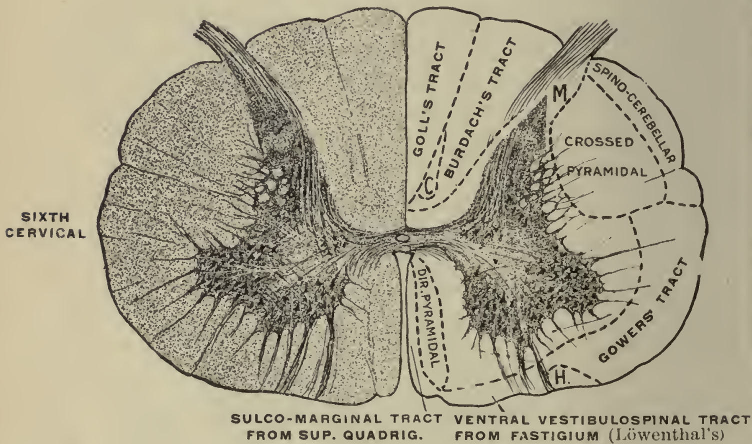


Fig. 123

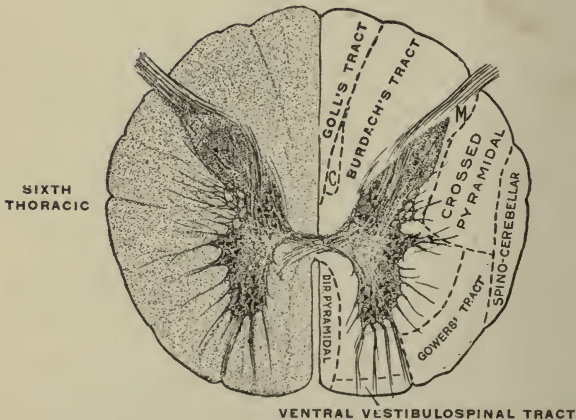
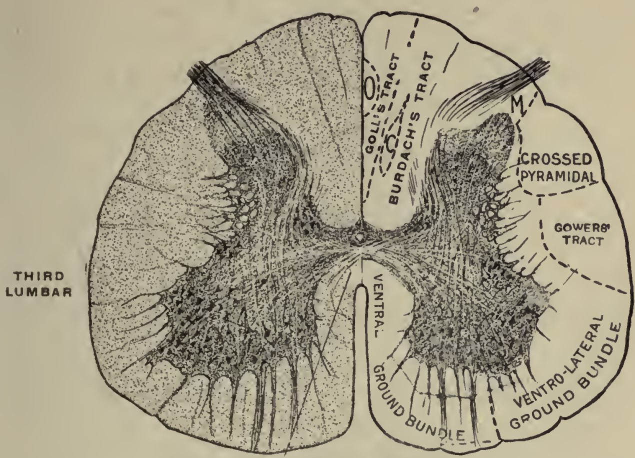


Fig. 124



Figs. 122, 123, and 124.—Sections of the spinal cord at the level of the sixth cervical, sixth thoracic, and third lumbar segments, the conducting tracts being indicated on the right side of each section: *C.* Comma tract of Schultze. *H.* Olivospinal tract of Helweg. *M.* Marginal tract of Spitzka-Lissauer. O. Oval field of Flechsig.

or margins of the foramen magnum and extends to the lower border of the first lumbar vertebra below, from which point it is continued as a narrow thread of gray substance, the filium terminalis. The spinal cord is 18 to 20 inches in length, and weighs one ounce.

The columns of the spinal cord are divided into three chief columns or funiculi. The **ventral, dorsal,** and **lateral.**

The columns are simply connecting pathways for the transmission of nerve impulses from the brain centres to spinal centres, and contain efferent, afferent, and association fibers. The course and connecting pathways of these nerve fibers within the white substance is seen to consist of numbers of medullated

nerve fibers, without possessing any neurilemma. They run in a vertical direction, and with their supporting frame-work of neuroglia and connective tissue—the latter is derived from the pia mater and blood-vessels—are grouped into bundles of axones, termed columns or tracts, which are marked off by fissures that can be seen with the naked eye on the surface of the cord.

The Structure of the Spinal Cord.—If a cross-section of the spinal cord be examined, it presents a central gray substance and a surrounding white substance, the former consisting of bodies of nerve cells and their non-medullated axones; the latter contain the medullated axones arranged in columns. The neuroglia pervades both the white and gray substance, and is the supporting tissue frame-work for the nerve cells, their dendrites, and axones.

THE GRAY SUBSTANCE OF THE CORD.—It is arranged within the spinal cord in the form of two crescents joined in the centre, or a figure resembling the letter H. The gray substance on either side extends nearly to the surface of the cord, surrounded by the white matter, the posterior projections are called the **dorsal or posterior horn,** and the anterior the **ventral** or **anterior horn;** the two halves of the gray substance are connected by a bridge of gray substance termed the commissure. The latter presents in its centre a narrow canal (neural) which extends the entire length of the cord. It is lined by cylindric epithelial cells and surrounded by a gelatinous material.

The anterior horn of the gray substance is broader than the posterior, and is completely surrounded by white substance. The posterior horn is narrower and approaches nearer to the surface of the cord than the anterior horn does, and is enclosed by a gelatinous substance called the substantia gelatinosa. In the lower cervical and thoracic portions of the cord the

gray matter is expanded into a projection called the lateral horn. This is seen on both sides. Microscopic examination of the gray substance will show that it is practically an aggregation of neurones—nerve cells with their dendrites and non-medullated axones, lymphatics, bloodvessels, all supported in a framework of non-neural tissue—the neuroglia.

Classification of nerve cells within the gray substance as regards their function: They are divided into **intrinsic, efferent,** and **afferent.**

The *intrinsic* cells are simply associative or connective in character, their processes enter the white substance horizontally, and give off branches which ascend and descend, reëntering the gray substance at different levels, where their axones again associate with the dendrites of other intrinsic cells.

The *efferent* motor cells is the term given to the cells found in the anterior horns, which are substations for the reception from the brain and other neurones, of motor impulses which they in turn conduct through their efferent axones, to the periphery, and promote activity in the muscles, glands, viscera, bloodvessels, as well as influence the growth, development, and metabolism (trophic) of the tissues.

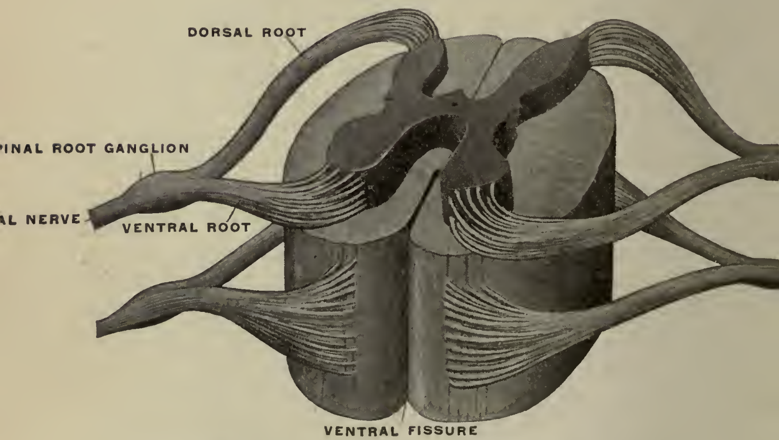
Afferent cells (sensor) is the name given to the cells of the posterior horn, which receive from the afferent nerves impulses and conduct the same by their afferent axones, to the cortex of the brain, giving rise to conscious sensations, as heat, pain, sensation of touch, etc.

The Spinal Nerves.—There are thirty-one pairs, divided according to the portion of the cord they arise from, as follows:

Cervical pairs	8
Thoracic pairs	12
Lumbar pairs	5
Sacral pairs	5
Coccygeal pairs	1
Total	31

All spinal nerves leave the spinal canal between the vertebra (intervertebral foramen). If one examines the spinal cord after removal, the spinal nerves will be seen to consist of two roots by which they arise from the sides near the anterior and posterior aspects of the cord. The two roots are named anterior or ventral and posterior or dorsal. The anterior and posterior roots join to form a single nerve trunk just before they leave the spinal canal. The dorsal root presents an enlargement near the point at which it joins the anterior root—a small grayish body called a ganglion. The roots do not leave the cord as a single rounded nerve, but are formed by the joining of four to six large nerve fibers.

Fig. 125



Showing origin of two pairs of spinal nerves (schematic). (Gray.)

The **posterior root** is sensor or afferent, and contains bundles of axones which convey impulses from the end-organs in the skin, mucous membranes, etc., after they have been received and conveyed by axones

and dendrites of the ganglia on its root, to the groups of cells in the dorsal horn of the spinal cord, and as we have mentioned before, these impulses ascend and descend by means of collateral branches, axones, and dendrites, communicating with other centres in the cord at different levels and ultimately reach the sensor areas in the brain. The **anterior root** is motor or efferent, and contains axones which transmit impulses from the groups of cells or centres in the anterior horn of the spinal cord, which are further conveyed by means of the efferent axones or nerve fibers to the periphery, where they stimulate muscles, glands, viscera, etc., into activity.

In other words, motor impulses arise in the cells of the anterior horn of the spinal cord and the motor area in the brain, and are conveyed toward the periphery of the body (muscles, glands, etc.), by means of neurones and their efferent processes. Sensor impulses arise within the structures of the skin, mucous membrane, etc., and are conveyed to the sensor group of cells in the dorsal horn of the cord, and are transmitted to the sensor and conscious areas in the brain by aggregations of neurones and their (afferent) processes coursing through the cord and brain substance.

The functions of the spinal cord are classified under **anatomatism, reflex action, association conduction, sensor conduction, motor conduction.**

Automatism, or Automatic, Autochthonic Action.—This is a function possessed by the spinal nerve cells whereby they influence the growth, development, and nutrition of the numerous cells of the various tissues, and thus maintain their normal physiologic activity. By this expression is meant a discharge of energy from the cells occasioned by a change in their environment, *i. e.*, in the chemic composition of the blood or lymph by which they are surrounded, and independent

of any excitation coming through afferent (sensor) nerves from the periphery. If the cell activity is continuous it causes an even and regular control over the processes of cell nourishment, development, etc. (trophic); muscle and vascular activity, which is spoken of as **tonus.**

Reflex Actions.—They are defined as the reception of nerve impulses transmitted to the nerve cells in the spinal cord and higher centres in the brain, by afferent (sensor) nerves; and the response of the nerve cells in the efferent centres to this stimulation, which result in nerve impulses being excited in the nerve cells, and conveyed by the efferent (motor) nerves, which pass from these cells to the structures to be innervated, and cause them to act, as, to muscles, causing contraction; to gland cells, secretion; to bloodvessels, increasing or decreasing their caliber; and to organs, increasing or decreasing their activity.

For any reflex act to be mechanically possible there must be present the following structures:

1. A surface to receive the stimuli: skin, mucous membrane, sense organ.

2. An afferent nerve fiber and cell, to convey the nerve-impulse arising as a result of the stimulus exciting the sense organ, etc., into activity.

3. An emissive cell, from which arises an (4) efferent nerve, distributed to a responsive organ, as muscle, gland, bloodvessel, etc.

In a more practical way the most simple reflex action can be explained as follows: If a muscle is stimulated by a strong current of electricity or pinched by an instrument, there is developed in the terminals of the afferent nerve a nerve impulse which is conveyed to the nerve cells in the posterior horn of the spinal cord, the dendrites of these cells transmit the impulse to the dendrites of the nerve cells in the anterior horn, where by means of a molecular disturbance

within the cells, energy is liberated and the nerve impulse is conveyed by the efferent nerve to the muscle and it contracts.

In most reflex actions there is and must be a more complex arrangement to account for the varied movements and functions of the different structures of the body which are taking place in response to external and internal stimuli. These complex reflexes are due to the nerve centres in the cord communicating by means of axones and dendrites of other cells with other higher centres at different levels of the cord, not only on the same but the opposite side; and a still more complex arrangement is produced, due to the fact that the centres in the medulla oblongata are in connection with the spinal centres by pathways of nerve fibers.

Thus reflex actions can be carried on without the individual being conscious thereof, or by the presence of the associated neurones other centres convey sensations to the brain, of which we are conscious, and the return impulse can excite a voluntary movement.

Reflex actions are controlled by centres in the brain (medulla) which transmit impulses to the spinal centres which either decrease or inhibit, either increase or accelerate their activity, thus regulating the reception of and response to nerve impulses by these centres which exert a controlling influence based on the needs of the physiologic functions of the human body.

Association Conduction.—The spinal cord is divided into segments which have a controlling influence over the physiologic functions of certain parts of the body, as the arm, leg, etc. These segments to properly work together and receive impulses from other reflex centres at different levels in the cord, which control movements in response to stimuli from other portions of the body, are held in communication by pathways

of nerve axones, termed association fibers, or this phenomenon is spoken of as **association conduction.**

Sensor Conduction.—This term is used in speaking of the pathways of afferent or sensor nerve fibers in the tracts of the spinal cord, which convey sensations of pain, external temperature, thirst, etc., from the skin, mucous membranes, etc., to the centres in the brain directly or indirectly, which are received by nerve cells in the cortex, giving rise to conscious sensations. These afferent pathways are not thoroughly understood, but the main one is called the **crossed pyramidal tract.**

Motor Conduction.—This is the term used in speaking of the pathways of efferent or motor nerve fibers in the tracts of the spinal cord which convey motor impulses from the cells in the cortex of the brain to centres in the spinal cord, that transmit nerve impulses to the muscles, glands, etc., and promote their activity. The main motor pathway is called the **direct pyramidal tract.**

THE ANATOMY AND PHYSIOLOGY OF THE BRAIN

The Brain (Encephalon).—The encephalon or brain is that part of the cerebrospinal system which, with its membranes, is contained in the cranium. It is composed of the cerebrum, cerebellum, pons Varolii, and medulla oblongata.

The Membranes of the Brain.—These are the dura, the pia, and arachnoid.

The **dura mater** is similar in structure to the dura of the cord, but differs from it in being closely attached to the cranial bones, forming, in fact, their inner periosteum. It is continuous with that of the cord at the foramen magnum, and with the external periosteum of

the cranial bones by means of its prolongations into the many foramina. It sends in various processes to support and separate the different parts of the brain, and its layers separate to form the cranial sinuses (venous). In the vicinity of the superior longitudinal sinus are to be found, on its outer surface, several glandulæ Pacchionii. They may also be seen on its inner surface and within the sinus, as well as on the pia mater.

The processes of the dura include the falces cerebri et cerebelli and the tentorium cerebelli.

The **arachnoid** is a similar membrane to that of the cord, and is separated, as in the cord, by the subarachnoid fluid from the pia. In front it leaves a space between it and the pia mater, viz., along the pons and interpeduncular region, the anterior subarachnoid space; and behind, between the medulla and and the cerebellum, is a second interval called the posterior subarachnoidean space. Both are connected with the ventricles of the brain by the foramen of Majendie in the pia mater covering the fourth ventricle.

The **pia mater** is a very vascular delicate membrane which dips into the sulci and forms the various choroid plexuses and also the velum of the third ventricle. The vessels of the brain run in the pia mater before entering the brain.

The brain, for purposes of description, includes the **cerebrum**, **cerebellum**, **medulla oblongata**, and **pons varolii.**

Medulla Oblongata.—The **medulla oblongata** is a pyramidal body, $\frac{3}{5}$ to 1 inch long, along its ventral surface, and $\frac{3}{5}$ inch thick. Its larger extremity is continuous with the pons above; its smaller extremity, directed downward and backward, blends with the spinal cord below. The anterior surface lies on the basilar groove of the occipital bone.

In front and behind it is marked by the continuation of the anterior and posterior median fissures of the cord, the former, with its process of pia mater, ending in a cul-de-sac just below the pons, the foramen cecum. The posterior expands into the fourth ventricle.

Each lateral half of the medulla is divided into areas.

The Areas of the Medulla Oblongata.—These are: (1) Ventral area; containing the pyramid. (2) Lateral area; containing the lateral tract olive. (3) Dorsal area; containing the funiculus gracilis, funiculus cuneatus, funiculus lateralis, and tuberculum cinereum.

The restiform body succeeds the gracile and cuneate nuclei in the dorsolateral part of the medulla oblongata. Its fibers converge from various sources and ultimately enter the cerebellum as its inferior peduncle. (Gray.)

The *Decussation of the Pyramids.* It is a term applied to the interlacing bundles seen on the ventral aspect of the medulla, at the junction of the medulla and the spinal cord. Ninety per cent. of the fibers cross the median line in this decussation to continue as the crossed pyramidal tract.

Structure of the Medulla Oblongata.—Gray and white matter are constituents of the medulla; the former is, in the internal part, continuous with the gray substance of the cord, while the white substance is external.

The Gray substance of the medulla, examined under the microscope, presents numerous groups of nerve cells similar in arrangement to the cells in the spinal cord, but they are not so regular, due to the changed course of the fibers of the white substance. These nerve cells are supported by neuroglia and connective tissue. The nerve cells give off axones which ascend to the brain and descend to the cord, conveying nerve-impulses to the brain (sensor or conscious), and transmitting other impulses from the brain to the

cord (motor or volitional), and others give off axones which form portions of the cranial nerves.

The white substance is composed of bundles of nerve fibers supported by a frame-work of neuroglia and connective tissue. These columns formed of bundles of nerve fibers are the connecting or conducting pathways coursing from the brain to the spinal cord, for the transmission of nerve impulses between the brain and the periphery.

The Pons Varolii.—The pons is a white mass on the anterior aspect of the brain stem placed between the medulla oblongata and the crura cerebri. It is convex from side to side, containing mostly transverse and longitudinal fibers. The transverse fibers are collected into rounded bundles, to continue as the middle peduncles into the white substance of the corresponding cerebellar hemispheres. The middle peduncles are commissural paths consisting of axones coursing in opposite directions connecting the nuclei with the cerebellum; then some axones pass into the opposite middle peduncle, forming uninterrupted commissural systems; again, a few fibers communicate with nuclei in the brain stem, notably the oculomotor, trochlear, and abducent cranial nerves.

The Structure of the Pons Varolii.—It consists of a central gray and white mass of nerve tissue, supported by neuroglia and connective tissue. Microscopically, bundles of nerve fibers and nerve cells can be seen in groups, the former coursing in a longitudinal and transverse direction, as continuations of the pathways of nerve fibers from the cord and medulla below, and the cerebrum and cerebellum above. The transverse bundles of nerve fibers in the pons convey impulses from the corresponding and opposite hemispheres of the brain. The nerve cells in the pons give off axones which form some of the cranial nerves.

Functions of the Medulla Oblongata and Pons Varolii.—The medulla and pons contain tracts of

nerve fibers which convey impulses from the brain and cerebellum to the spinal cord. The anterior portion of the medulla and pons contain pathways for the transmission of volitional efferent nerve impulses from the higher centres in the brain to the spinal cord; the posterior portion contains pathways for the conduction of afferent nerve impulses from the spinal cord to the brain. The medulla and pons contain groups of nerve cells and nerve fibers, called **nerve centres**, which are in connection with and can be influenced reflexly by other nerve impulses received from associated groups of nerve fibers.

The Cerebellum.—The **cerebellum** is the largest portion of the hind-brain. It lies in the posterior fossa of the skull separated from the occipital lobes of the cerebrum by the tentorium cerebelli. It is behind the pons and medulla oblongata, connected with the former through the middle peduncles, and partly embracing the latter; and connected with the restiform body (medulla) by means of the inferior peduncles; the superior peduncles contain fibers which pass from the cerebellum to the tegmentum of the midbrain in front.

The cerebellum is divided into a medial segment, the **vermis or worm**; two **lateral hemispheres**; a **ventral** and **dorsal notch**; and a superior and inferior surface; and is subdivided into lobes and fissures.

The arbor vitæ is the name given to the arrangement of the white substance of the cerebellum, seen on a median section. The cerebellum weighs 5.8 ounces in the male; and 5.4 ounces in the female. The proportion between the cerebellum and cerebrum is 1 to 7.5 in the adult; 1 to 8.5 among eminent men; 1 to 20 in the newborn. (Gray.)

The Structure of the Cerebellum.—Examined on a cross-section, the cerebellum consists of gray and white matter. The gray matter is external with the

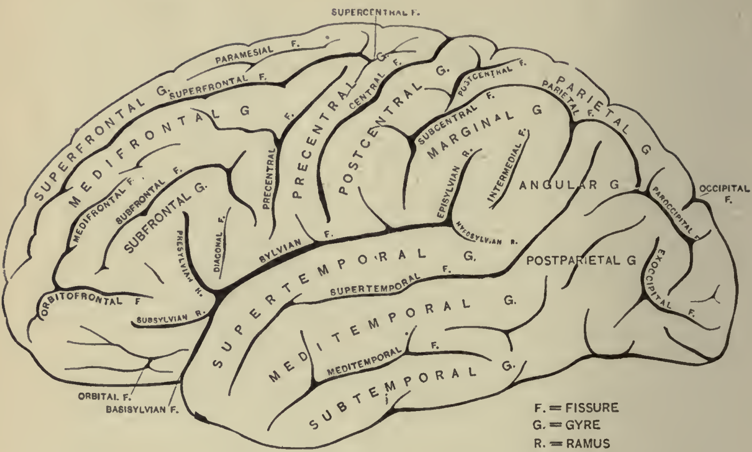
white matter in the centre. The gray substance consists of masses of nerve cells, their axones, and dendrites. The cells are arranged in layers. The white matter consists of nerve fibers which pass in different directions and connect various portions of the cerebellum with one another. Nerve fibers are grouped in bundles and connect cerebellum with the cerebrum, pons varolii, medulla oblongata, and spinal cord.

The Function of the Cerebellum.—It is the centre for maintaining the equilibrium of the body, by sending out nerve impulses, which cause a combined action of groups of muscles that enable the body to stand erect without swaying, and assist in the various and complex movements seen in walking, dancing, running, etc. The centres in the cerebellum are reflexly influenced by nerve impulses arising in the end-organs of the skin, retina of the eye, tactile (touch) sense, and the labyrinth of the ear. These impulses are transmitted to the cerebellum by afferent nerve fibers and they stimulate the centres to activity and the nerve impulses are conveyed by efferent nerves, though the pons, medulla, and spinal cord and nerves to the general muscle system.

The Cerebrum.—The cerebrum is the largest part of the brain, and consists of two lateral halves or hemispheres, separated by the great longitudinal fissure and connected to each other by a great commissure, the **corpus callosum.** The latter constitutes a great system of association nerve fibers for the bilateral coördination of corresponding parts of the nerve cells in the cortex. The hemispheres are subdivided into lobes, and the latter present over their entire surfaces convoluted eminences, the **gyri** or **convolutions,** separated by depressions, the **sulci or fissures.** (See Figs. 126 and 127.)

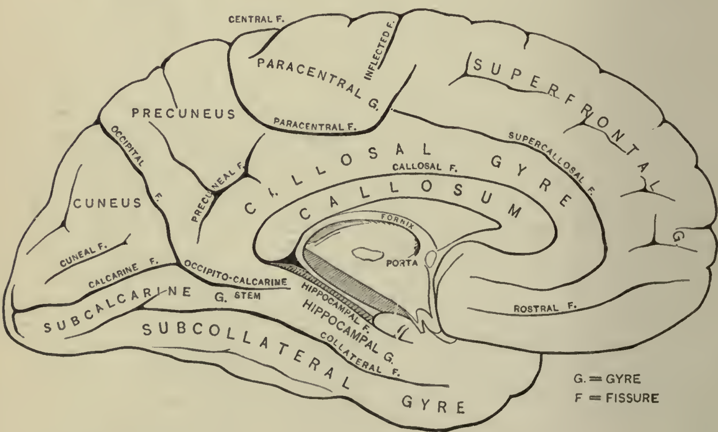
The cerebrum, as a whole, is convex from before backward and from side to side, narrower in front

Fig. 126



Fissures and gyres of the lateral surface of the left hemicerebrum. (Gray)

Fig. 127



Fissures and gyres of the mesal surface of the left hemicerebrum. (Gray.)

than behind. Its inferior surface is flattened and overlaps the midbrain and cerebellum, from which it is separated by the tentorium cerebelli. The outer surface, including the fissures, is composed of gray matter, the cortical substance, while the interior is of white matter.

Lobes of the Cerebrum.—The lobes are the **frontal,** the **parietal,** the **occipital,** the **temporal,** and the **central lobe** or **Island of Reil.**

The Frontal Lobe.—The lateral surface is separated behind from the parietal lobe by the central fissure or the fissure of Rolando, and below, from the temporal lobe by the Sylvian fissure, in part, and rests on the orbital plate of the frontal bone.

The Parietal Lobe.—The lateral surface is bounded in front by the central fissure, below by the Sylvian fissure, above by the back part of the internal border; it is only partially separated from the occipital lobe by the occipital fissure, merging gradually into the temporal lobe.

The Occipital Lobe.—The lateral surface is bounded anteriorly by the occipital fissure, which partially separates it from the parietal lobe, also the para-occipital and exoccipital fissures are seen extending into the lobe.

The Temporal Lobe.—The lateral surface is bounded by the basisylvian and Sylvian fissures and by the ventrolateral border; posteriorly, it merges into the adjacent parietal and occipital lobes.

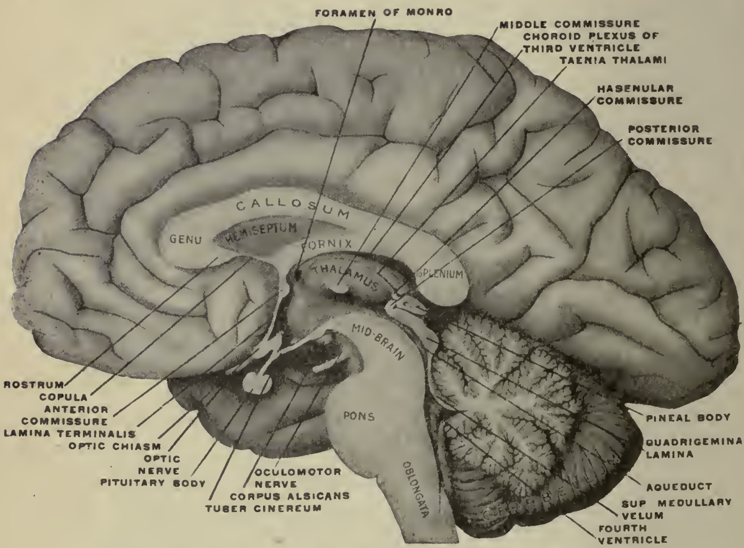
The Island of Reil (central lobe or insula).—This is seen after separating the lips of the sylvian cleft, after raising the frontal lobe; it is overlapped by the opercula; the latter removed, the island of Reil is seen as a tetrahedral-shaped mass with its apex directed forward and upward.

The Rhinencephalon or Olfactory Lobe.—This constitutes the central olfactory structures, as distin-

guished from the rest of the fore-brain. It comprises: (1) Peripheral parts; (2) central or cortical portions; the former is divided into **pre-** and **postolfactory** portions.

THE VENTRICLES OF THE BRAIN.—The ventricles of the brain are narrow cavities enclosed with the substance of the cord. They are filled with cerebro-

FIG. 128



Mesal aspect of a brain sectioned in the median sagittal plane.

spinal fluid and communicate with one another by means of narrow canals and foramen. The ventricles are called the **lateral**, **third**, and **fourth**.

The **lateral ventricles** are serous cavities, have a thin lining membrane covered by a layer of epithelium cells (*ependyma*), which secretes a serous fluid. They are contained one in each hemisphere, separated by

the *septum lucidum*, and each is divided into a *body* and *three cornua*, an anterior, posterior, and middle. The foramen of Monro connects them with the third ventricle.

The **third ventricle** is derived from the primitive fore-brain vesicle, except that portion which also enters into the formation of the lateral ventricles. It is a narrow space between the two thalami and hypothalamic gray, limited in front by the terma, behind continuous with the aqueduct of Sylvius, and laterally is continuous with the lateral ventricles through the **foramen of Monro.**

The **fourth ventricle** is an irregularly pyramidal-shaped cavity, with a lozenge-shaped base, and ridge-like apex; found between the medulla oblongata and the back part of the pons varolii in front and the cerebellum behind. It is divided into a roof and a floor. Below the fourth ventricle is continuous with the small central canal of the cord and post-oblongata (in part); above it communicates with the third ventricle by means of the aqueduct of Sylvius. The fourth ventricle has an opening through the tela choroidea, which permits of communication with the subarachnoid space; it is called the **foramen of Majendie.**

The Structure of the Cerebrum.—It consists of masses of gray and white substance. The gray being outside, makes up the **cortex.** The gray substance is composed of layers of nerve cells and nerve fibers, with their axones and dendrites embedded in a net-work of neuroglia. The nerve fibers may be amyelinic or myelinic. Their direction may be either transverse or vertical.

The white substance of the cerebrum is composed of myelinic nerve fibers interwoven into an intricate series of pathways, which are classified into (1) **association** fibers, which connect neighboring or distant

portions with the same half of the cerebrum; (2) commissural fibers which pass between the two halves of the cerebrum and connect similar areas within each; they cross in the middle line of the brain and form commissures; (3) **projecting** fibers, which connect the cerebrum with lower nerve centres in the brain and spinal cord, and other fibers that connect the lower centres with the brain.

The Weight of the Brain.—The average weight of the human brain in the adult male is 1400 grams (49.5 ounces); in the female, 1250 grams (44 ounces); in the newborn, 400 grams (14.1 ounces).

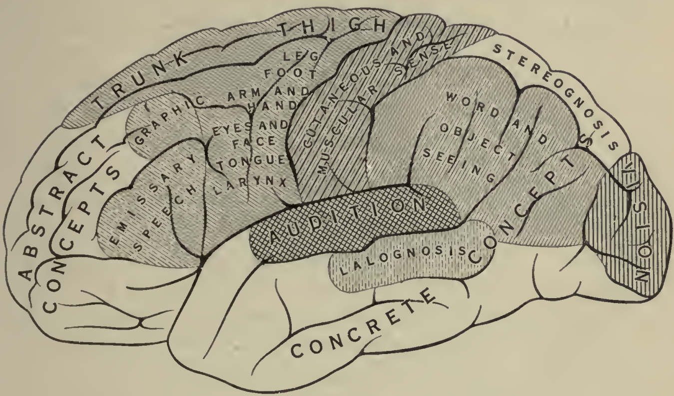
The Functions of the Cerebrum.—The functions of the cerebrum have been discovered as a result of a study of the anatomic development of the brain, and examination of brains of various animals, human beings, etc., and a study of diseases or injured brains, certain parts of which have been rendered inactive by the destruction of nerve cells and their processes; such a destruction of tissue has been manifested in different parts of the body by an interference or loss of the function of the extremity, etc., to which the nerve leading from or to the diseased region in the brain is distributed. Thus it has been determined that certain areas of the brain contain nerve cells and nerve fibers which control definite functions of the body, and are grouped into definite areas, irregularly marked off by fissures, and correspond to the convolutions seen on the surface of the cerebrum. These areas are spoken of as **the cortical localization of function.**

Cortical Localization of Function.[1]—**Motor Area.**—Comprises the precentral gyre and parts of the frontal gyres adjacent thereto, together with the paracentral, and the adjacent portion of the superfrontal gyre on its inner aspect. This area comprises the centres for

[1] See Figs. 129 and 130, page 365.

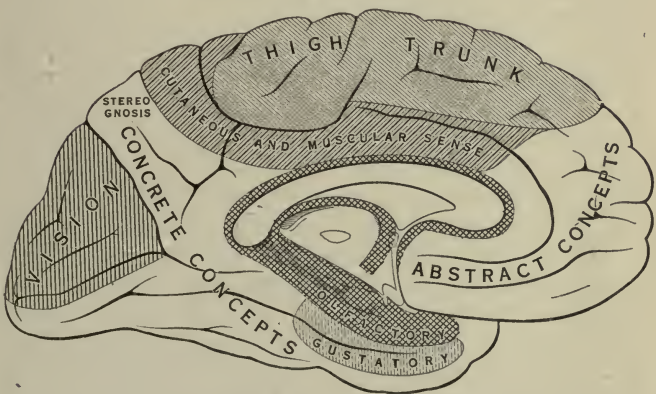
the muscle control of the following parts of the body located as follows:

FIG. 129



Lateral view of left cerebral hemisphere, showing localization of functions (Gray.)

FIG. 130



Mesal view of left cerebral hemisphere, showing localization of functions.

Lower Limbs.—Back part of precentral and paracentral fissures.

Trunk.—Toward the front part, both on the under and in the back superfrontal fissure.

Upper Limbs.—Midportion of precentral fissure.

Facial.—Front part of precentral fissure.

Tongue, Larynx, Muscles of Mastication, Pharynx.—Frontal opercular part.

Movements of Head and Eye.—Medifrontal fissure, adjacent to precentral fissure.

Owing to a decussation of the pyramidal (motor) tracts in their course to the primary motor centres, the motor centres in one cerebral hemisphere control the movements of the opposite side of the body.

Sensor Areas.—Tactile and temperature impressions. Postcentral fissure, in corresponding order with the neighboring precentral motor area; the postcentral (sensor) and precentral (motor) fissures are so closely associated in the highest category of the reflex arc system represented in the cerebral cortex, that they are included under the term of **somesthetic** or **sensomotor area** devoted to the registration of cutaneous impressions, impressions from the muscles, tendons, and joints; in short, the sense of movement.

Stereognostic Sense Area (concrete perception of the form and solidity of objects).—Parietal fissure and its extension in the precuneus on the inner aspect.

Auditory Area.—Middle third of supertemporal, and adjacent transtemporal fissures in the Sylvian cleft.

Visual Area.—Calcarine fissure and cuneus as a whole.

Olfactory Area.—Uncus, frontal part of hippocampus, indusium, subcallosal fissures, parolfactory area, and anterior perforated substance.

Gustatory Area.—Probably in region of the olfactory area in the temporal lobe (uncinate and hippocampal fissures ?) (not definitely settled).

Language Areas.—Emissive (articular) centre for speech (control of muscles used in speech; larynx,

tongue, jaw muscles). Junction of subfrontal fissure with the precentral fissure.

Auditory Perceptive Centre (word deafness, also the lalognostic or word understanding centre).—Marginal fissure and adjacent parts of super- and meditemporal fissure.

Visual Receptive Centre (word blindness).—Angular fissure.

Emissive "Writing" Centre.—Medifrontal fissure, in front of motor area for the upper limb (this has not been definitely proved or accepted).

Language Arrangement Centre.—**Island of Reil** or insular association area serving to connect the various receptive sense areas relating to the understanding of the written and spoken word with the somesthetic sensormotor emissary centre related to articulate speech and writing.

Association Areas.—Under this heading are included the **frontal association area** concerned, so far as is known, with the powers of thought in the abstract, creative, constructive, philosophic, the seat of the will, memory. The **parieto-occipito-temporal area** is concerned with the powers of conception of the concrete, for the comprehension of analogies, comparing, generalizing, and systematizing things heard, observed, and felt (Gray).

Sleep.—Different theories have been proposed to account for the causes of sleep, none of which has been wholly satisfactory.

The most generally accepted theory is based on the decline in the irritability of the nerve cells of the brain and associated sense organs, and the development of fatigue conditions, the result of prolonged activity (Brubaker).[1]

The Peripheral Nerve System.—The peripheral nerve system includes those nerve trunks which

[1] See chapter on arteries and veins for blood-supply of brain and its membranes.

convey impulses to and from the centres in the brain to the structures of the body. They are divided into **cranial nerves,** which do not pass through the spinal cord, but leave the brain direct from various locations; and **spinal nerves,** which derive their nerve fibers from the spinal cord and pass out of the spinal canal by way of the foramen between the vertebra.

The Cranial Nerves.—The cranial nerves consist of twelve pairs, as follows:

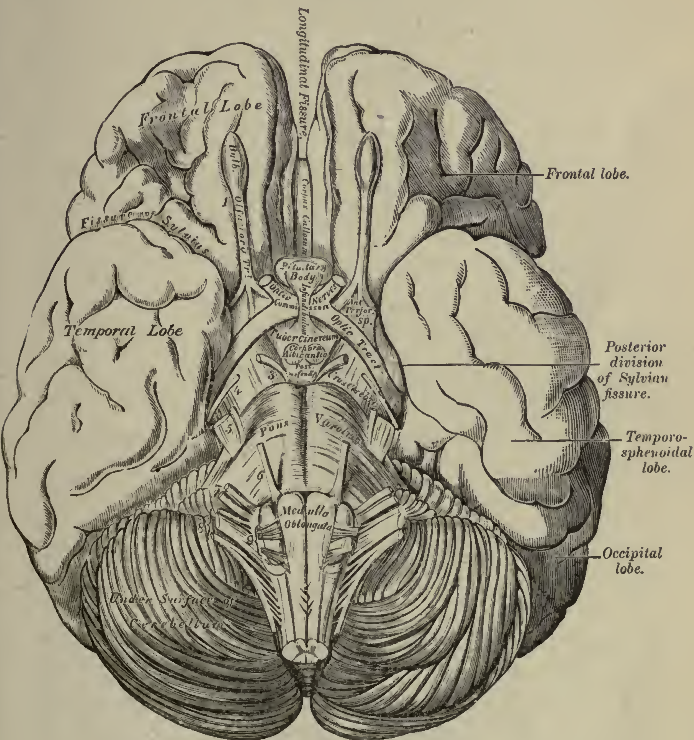
I. Olfactory (fila).
II. Optic.
III. Oculomotor.
IV. Trochlear.
V. Trigeminal.
VI. Abducent.
VII. Facial.
  Nervus intermedius.
VIII. Acoustic.
  1. Cochlearis.
  2. Vestibularis.
IX. Glossopharyngeal.
X. Vagus.
XI. Spinal accessory.
  1. Accessory to vagus.
  2. Spinal part.
XII. Hypoglossal.

These nerves have each a superficial and a deep origin. The former corresponds to its point of attachment at the surface of the brain; the latter to certain nuclei or collections of nerve cells in the structure of the brain. The superficial origin only will be mentioned.

The Olfactory Nerves (First).—The **olfactory nerves** or **fila** are the special nerves of the sense of smell. Twenty in number on each side. They are distributed to the olfactory region in the upper part

of the superior turbinated process of the ethmoid and corresponding portion of the nasal septum. These filaments represent the axones of the olfactory cells

Fig. 131



Base of brain, showing superficial origin of cranial nerves.

and pass through the cribiform plate of the ethmoid bone to join the under surface of the **olfactory bulb,** which rests on the cribriform plate, and is the oval mass of a grayish color that forms the anterior extremity

of a slender process of brain substance, called the **olfactory tract**. The olfactory nerves differ in structure from the other nerves, containing only amyelinic fibers.

The Optic Nerves (Second).—The fibers of the optic nerves, the special nerve of the sense of sight, are situated in the retina; they start as the central processes of the ganglion cells which converge and pierce the choroid and sclera as a cylindric cord. The point of emergence is situated a little internal to the posterior pole of the globe. Passing through the orbital fat, in an inward and backward direction, it passes through the optic foramen to end in the optic chiasm or commissure. The **optic chiasm** is somewhat quadrilateral in shape, rests on the olivary eminence and the diaphragma sellæ, being bounded above by the lamina terminalis; behind, by the tuber cinereum, on either side by the anterior perforated substance. Within the chiasm the fibers cross as follows: Those from the nasal side of the left and right halves of the retina cross in the centre, to the opposite optic tract; those from the temporal side of the right and left eyes pass backward without crossing, to end in the optic tract of the same side.

The optic tract passes back to areas of the brain where the nerve impulses are conveyed to the cuneus (the area for the sense of sight in the cortex) by means of another pathway, the **optic radiation**. By connections with other nerve centres in the brain the optic tract communicates with the origin of the nerves which influence the muscles that control the movements of the eye-ball.

The Oculomotor (Third).—The oculomotor arises superficially from the crus anterior to the pons, its deep origin being a gray nucleus in the floor of the aqueduct of Sylvius. It runs to the outer side of the posterior clinoid process of the sphenoid bone, enters

the cavernous sinus, runs above the other nerves in its outer wall, and divides into *two branches,* which enter the orbit between the two heads of the external rectus. It is joined in the sinus by sympathetic filaments. The *superior* branch crosses the optic nerve to supply the superior rectus and levator palpebræ muscles. The *inferior* divides into three parts—one for the inferior oblique, one to the inner, and one to the lower recti muscles. The first supplies the motor root of the lenticular ganglion of the sympathetic system.

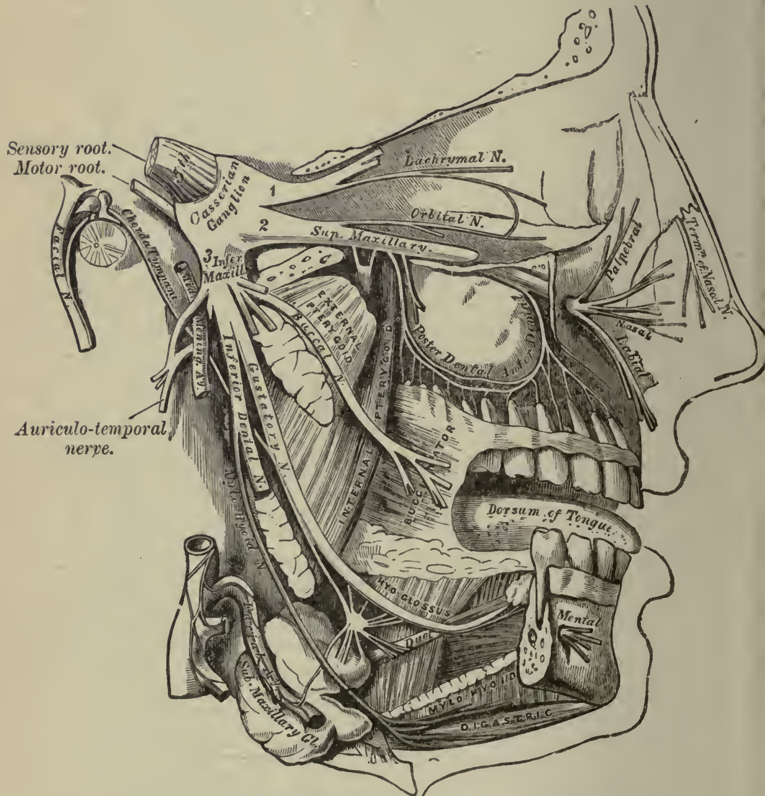
THE TROCHLEAR (FOURTH).—The trochlear nerve has an apparent origin from the upper side of the valve of Vieussens, and a deep from the floor of the aqueduct of Sylvius. The two nerves communicate by a transverse band on the valve of Vieussens. The nerve pierces the dura after crossing over the crus, enters the cavernous sinus, in whose outer wall it lies between the ophthalmic and third nerves, then crosses the latter to enter the orbit through the sphenoidal fissure above the external rectus, and enters the superior oblique muscle.

THE FIFTH NERVE (TRIFACIAL).—The fifth or trifacial is the largest of all the cranial nerves, and arises by two roots, a motor and a sensor. The former is small, and the latter has the Gasserian ganglion upon it. Both arise from the side of the pons superficially, the smaller root above the larger, some transverse fibers of the pons separating the two. This nerve conveys both motion and sensation. At the apex of the petrous portion of the temporal the large root forms the *Gasserian ganglion;* the smaller does not join in the ganglion, but runs below it to join, just below the foramen ovale, the lowest trunk proceeding from the ganglion.

The **Gasserian ganglion** lies in a hollow near the apex of the petrous portion of the temporal bone, the large

superficial petrosal nerve, and the motor root lying below it. It receives branches from the carotid

Fig. 132



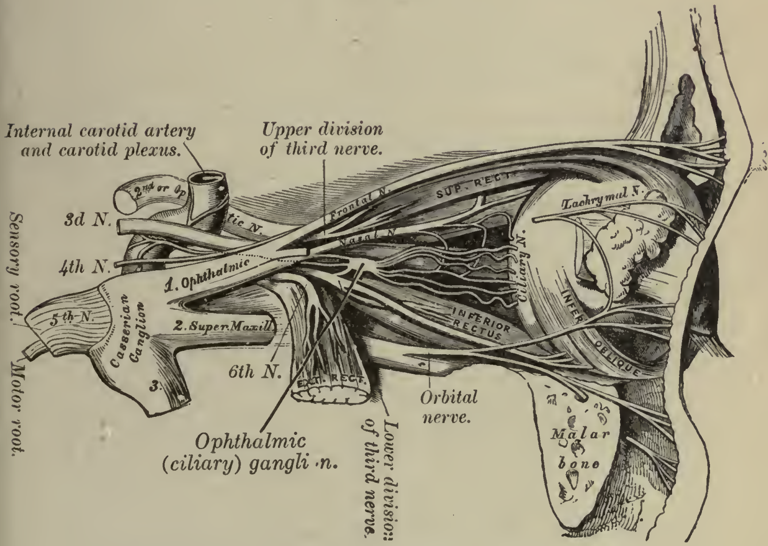
Distribution of the second and third divisions of the fifth nerve and submaxillary ganglion. (Gray.)

plexus. Small twigs pass to the dura mater. This ganglion sends off three large branches, viz., the ophthalmic, superior maxillary, and inferior maxillary.

The first two confer sensation, the third, motion and sensation.

The **ophthalmic nerve**, or first division of the fifth nerve, is sensor and the smallest branch of the ganglion. It is flattened, about 1 inch long. It receives *filaments from* the *cavernous plexus*, and gives off *filaments* to the *third* and *sixth*, and sometimes to the *fourth* nerve,

Fig. 133



Nerves of the orbit and ophthalmic ganglion. Side view. (Gray)

and a *recurrent* branch running in the tentorium cerebelli with the fourth. Finally, it divides into the frontal, lacrymal, and nasal nerves, which pass through the sphenoidal fissure into the orbit.

The **second division of the fifth nerve** (superior maxillary) is sensor, and enters the foramen rotundum,

crosses the sphenomaxillary fossa, and, as the **infra-orbital,** traverses the canal, emerges from the foramen to end on the face in the *palpebral, nasal,* and *labial* branches—the first set, to lower lid; the second, to side of nose; and the third, to upper lip.

The **orbital** or temporomalar branch enters the orbit by the sphenomaxillary fissure, and divides into two branches, which pierce the malar bone.

The **alveolar** or superior dental nerves are three: The *posterior, middle,* and *anterior,* which supply the upper row of teeth.

The **inferior maxillary nerve** (third division of the fifth) is the largest branch, and arises by two roots—a large sensor root from the Gasserian ganglion and the motor root of the fifth. This nerve divides into two trunks, anterior and posterior. The *anterior* gives off the masseteric, the buccal, the deep temporal, and the two pterygoid nerves.

The *posterior* trunk of the inferior maxillary is mostly sensory. It divides into the auriculotemporal, gustatory, and inferior dental; the last supplies the lower row of teeth.

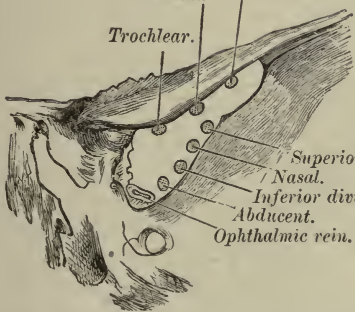
The **gustatory** or **lingual** nerve lies at first beneath the external pterygoid, internal to the dental nerve. Here a branch from the dental may cross the internal maxillary to join it. The chorda tympani also joins it.

The nerve now runs along the inner side of the ramus of the jaw, and crosses the upper constrictor to the side of the tongue above the deep part of the submaxillary gland; lastly, it runs below Wharton's duct, and superficially along the side of the tongue to its apex. It communicates with the facial through the chorda tympani, the submaxillary ganglion, inferior dental, and hypoglossal. It supplies the mucous membrane of the mouth and tongue (anterior two-thirds), the gums, sublingual gland, and the

filiform and fungiform papillæ in the mucous membrane on the back of the tongue.

THE SIXTH NERVE.—The sixth or abducens has an apparent origin in the groove between the pons and medulla. It runs to the lower and outer part of the dorsum sellæ, and traverses the floor of the cavernous sinus external to the carotid artery, and, receiving branches from the cavernous and carotid plexuses, enters the orbit by the sphenoidal fissure

FIG. 134

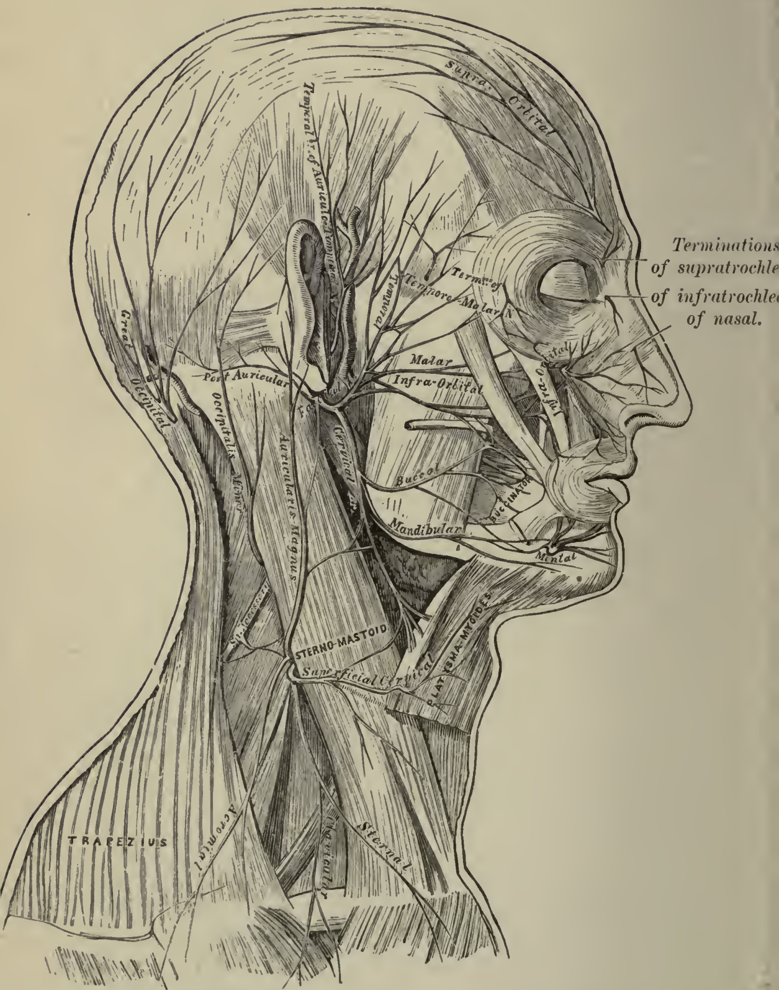


Relations of structures passing through the sphenoidal fissure. (Gray.)

between the two heads of the external rectus; it receives a branch from the ophthalmic nerve, and supplies the above-named muscles.

THE SEVENTH NERVE.—The seventh or facial has a superficial origin from the depression between the olivary and restiform bodies of the medulla oblongata. Between it and the eighth is the *pars intermedia,* which joins the facial in the auditory canal. The nerve runs outward to the internal meatus, where it runs in a groove on the auditory nerve, enters the aqueductus Fallopii, and emerges at the

Fig. 135



The nerves of the scalp, face, and side of the neck. (Gray.)

stylomastoid foramen. It presents within the aqueduct, near the hiatus Fallopii, a reddish enlargement, the *geniculate ganglion.* Outside the cranium it runs forward in the parotid gland, and divides behind the ramus into the *cervicofacial* and *temporofacial* divisions. In the parotid and vicinity the radiating branches form the pes anserinus.

The facial nerve supplies all the muscles of expression of the face.

The Auditory Nerve.—The eighth or auditory is the special nerve of the sense of hearing. Superficially it appears at the lower border of the pons, external to the facial. It has two roots—one from the inner side of and one from the front of the restiform body. It runs to the internal auditory meatus with the facial nerve, the two being separated by the pars intermedia and the auditory artery. The nerve in the meatus divides into a *cochlear* and a *vestibular* branch, whose distributions within the ear are described under the special sense of hearing.

The Ninth Nerve.—The ninth or glossopharyngeal arises superficially by several filaments from the groove between the olivary and restiform bodies at the upper part of the medulla; deeply through the lateral tract to a gray nucleus in the floor of the fourth ventricle.

The nerve runs through the middle part of the jugular foramen with the vagus and spinal accessory, in a separate sheath, and here presents two successive ganglionic enlargements, the jugular and the petrous ganglia. Outside the cranium it passes between the jugular vein and the internal carotid artery, descending in front of the latter, and beneath the styloid process and its muscles, to the lower border of the stylopharyngeus, and supplies the mucous membrane of the tongue. It then crosses this muscle and divides into branches beneath the hyoglossus. In the jugular

foramen it grooves the lower border of the petrous portion of the temporal bone.

The Pneumogastric Nerve.—The tenth, vagus, or pneumogastric is both motor and sensor. Its apparent origin is by twelve to fifteen filaments below, and in the line of the origin of the ninth; its deep origin is from a nucleus in the lower part of the fourth ventricle. It passes through the jugular foramen in the same sheath with the spinal accessory, a partition separating them from the ninth, and develops the *ganglion of the root* of the vagus. Emerging from the foramen, it forms the *ganglion of the trunk* of the vagus.

The *ganglion of the root* (ganglion jugulare) is gray in color and spherical, its diameter about two lines. It has branches of communication with the accessory part of the spinal accessory, with the petrous ganglion of the ninth, with the facial, and with the superior cervical ganglion of the sympathetic.

The *ganglion of the trunk* (ganglion cervicale) is larger, of a reddish color, and cylindrical form. Its surface is crossed by the accessory portion of the eleventh, and it communicates with the hypoglossal, the upper two cervical, and the sympathetic nerves.

The vagus then descends between the internal carotid artery and the jugular vein to the thyroid cartilage, then between the vein and the common carotid to the root of the neck; where it enters the thorax and gives off branches to the heart (cardiac plexuses), lungs (pulmonary plexuses), and esophagus; it then passes through the esophageal opening in the diaphragm to enter the abdominal cavity where it gives off branches to the solar plexus, the stomach, liver, spleen, kidneys, suprarenal glands, and pancreas.

The Eleventh Pair.—The eleventh, or spinal accessory, consists of a *spinal* portion and an *accessory*

part to the vagus. The *latter* part arises as five or six filaments from the lateral tract of the medulla, below the origin of the vagus.

The *spinal portion* arises from the lateral column of the cord as low as the sixth cervical nerve, the fibers being connected with the anterior horn of gray matter. This part then ascends, between the posterior nerve roots and the ligamentum denticulatum, through the foramen magnum, then out again by the jugular foramen, lying in the sheath of the vagus, and here communicates with the accessory portion. After its exit from the skull it crosses the internal jugular vein and pierces the sternomastoid to end in the trapezius muscle.

THE HYPOGLOSSAL.—The twelfth, or hypoglossal, nerve arises by ten to fifteen filaments from the groove between the pyramid and olivary body in the medulla. The deep origin is from a nucleus in the floor of the fourth ventricle. The filaments form two bundles which pierce the dura separately and unite in the anterior condylar foramen. The nerve descends behind the internal carotid artery and internal jugular vein, closely bound to the vagus.[1]

The Spinal Nerves.—The spinal nerves consist, on each side, of eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal, in all thirty-one pairs, which arise from the cord by two roots, *anterior* and *posterior*. The latter are the larger, and are supplied with ganglia. The suboccipital or first cervical nerve has no ganglion. The two roots unite just beyond the ganglion, and the resulting *trunk* divides into *two divisions*, anterior and posterior, each containing fibers from both roots, sensor and motor. The *posterior division* divides into an *external* and an *internal* branch. The *anterior divisions* in the dorsal region remain separate, but elsewhere they unite into plexuses.

[1] See Fig. 131 for origin of spinal nerves.

They are larger than the posterior. Each division is connected with the sympathetic ganglia along the vertebral column, by means of nerve trunks called rami communicantes. (See Sympathetic System, p. 385.)

The Cervical Plexus.—The cervical plexus is formed by the anterior divisions of the upper four cervical nerves, which emerge between the scalenus medius and rectus anticus major. It lies upon the scalenus medius and levator anguli scapulæ, beneath the sternomastoid. Each nerve except the first divides into a branch for the nerve above and one for the nerve below. The anterior division of the first (suboccipital) nerve grooves the atlas beneath the vertebral artery, and joins the second, supplying the rectus lateralis and recti antici muscles. It communicates with the sympathetic vagus, and hypoglossal nerves.

Its branches are *superficial* and *deep*.

The *superficial* are divided into ascending and descending.

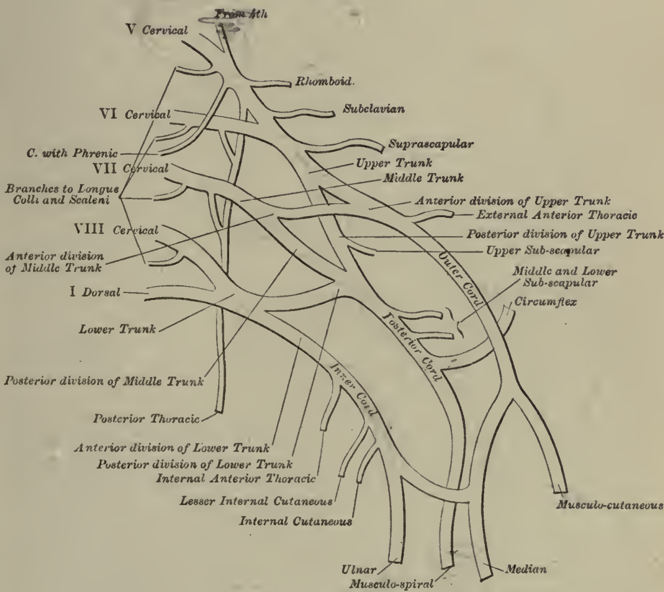
Ascending Branches. — (*a*) The **superficialis colli**, (*b*) **auricularis magnus** (great auricular), (*c*) **occipital minor.**

Descending Phrenic, from the third, fourth, and fifth, descends on the scalenus anticus, then between the subclavian artery and vein, and crosses the internal mammary artery. It then crosses in front of the root of the lung and runs between the pericardium and mediastinal pleura to the diaphragm.

The Brachial Plexus. — The brachial plexus is formed by the anterior divisions of the lower four cervical and first thoracic, as follows: The fifth and sixth form an upper; the seventh, a middle; and the eighth cervical with first dorsal a lower trunk. Each of these trunks then separates into an anterior and a posterior branch.

The anterior branches of the upper and middle trunks form the *outer cord* of the plexus; the anterior branch of the lower, the *inner cord;* of the posterior cord it is variously stated that the posterior branches of all three trunks form it, or that the posterior branches of the upper and middle trunks form it, while the

Fig. 136



Plan of the brachial plexus. (Gray.)

posterior branch of the lower trunk joins the musculo-spiral nerve. It is altogether a matter of dissection.

The plexus is at first between the anterior and middle scaleni, then above and external to the subclavian artery. It passes behind the clavicle and subclavius, lying on the subscapularis and serratus magnus muscles. The *cords* lie external to the first part of the axillary

artery, but on three sides of the second part of that vessel.

The branches of the brachial plexus supply the muscles of arm, forearm, fingers, and the muscles of the chest.

THE LUMBAR PLEXUS.—The **lumbar plexus** is formed in the substance of the psoas muscle, in the following manner: Each of the first four lumbar nerves divides into an *upper* and a *lower* branch. Just before dividing the *first* receives the twelfth thoracic nerve, and the *third* and *fourth* send each a branch to the nerve below.

The *upper* branch of the first subdivides into the *iliohypogastric* and *ilioinguinal* nerves. The *lower* branch of the first passes downward and subdivides into two branches, one of which unites with the *upper* branch of the second to form the *genitocrural* nerve. The other unites with the *lower* branch of the second to form a cord. This cord passes downward, and gives off the *external cutaneous* nerve and a branch to the obturator, after which it unites with the upper branches of the third and fourth to form the *anterior crural* nerve. The lower branches of the third and fourth unite to form the *obturator* nerve.

The branches derived from the above plexus innervate the skin and muscles over the anterior and internal aspect of the thigh, leg, instep, and external genital organs.

THE SACRAL PLEXUS.—The **sacral plexus** is formed by the anterior divisions of the *first, second, third,* and *part* of the *fourth* sacral nerves, together with the lumbosacral cord.

The **lumbosacral cord**, with the first, second, and part of the third sacral nerve, is continued into the upper great branch of the plexus, and the remainder of the plexus forms the lower or smaller branch.

The branches from this plexus supply the muscles and skin over the buttocks, back of thigh and leg, and the sole of the foot.

THE SYMPATHETIC NERVE SYSTEM

The sympathetic system consists of numbers of ganglia connected with one another by extension of their nerve trunks. It is not an independent system for the conveyance of nerve impulses, but is in relation with the cerebrospinal system of nerves through communicating branches.

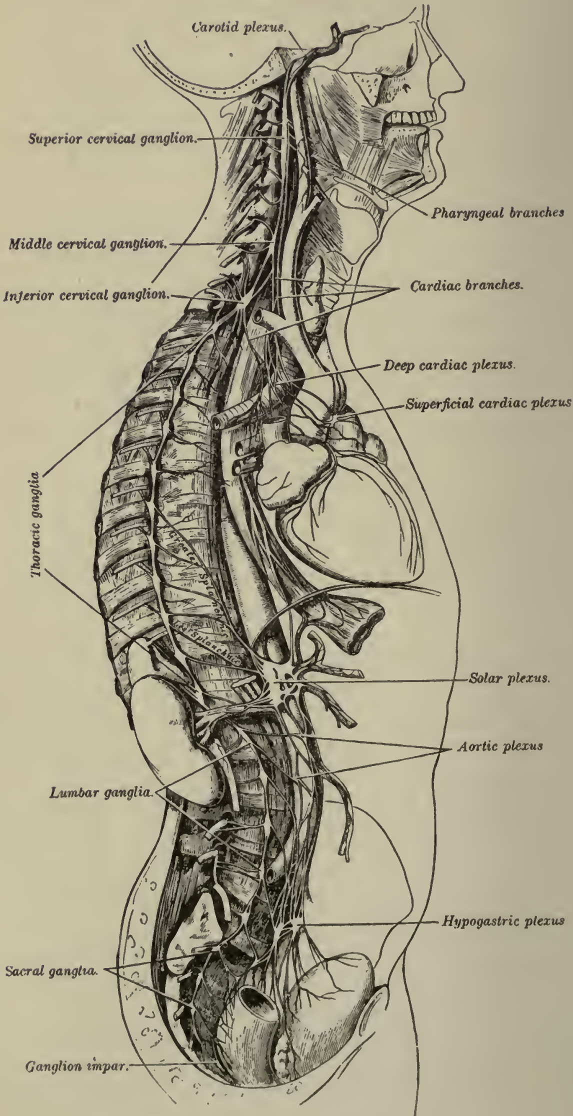
The ganglia are classified as central ganglia which are arranged on either side of the spinal column, and are connected to each other by nerve trunks, forming the **gangliated cord.** The central ganglia extend from the base of the skull to the coccyx, and communicate with the spinal nerves by means of nerves called **rami communicantes.**

The ganglia of the cord are classified for purpose of study into the following groups:

Cervical portion	3 pairs of ganglia.
Thoracic portion	10 to 12 pairs of ganglia.
Lumbar portion	4 pairs of ganglia.
Sacral portion	4 or 5 pairs of ganglia.

The ganglia of the sympathetic system are further arranged into minute plexuses called the **three great gangliated plexuses.** They are situated in the thoracic and abdominal cavities and receive interconnecting nerve trunks which form the following plexuses: (1) The **cardiac,** which receives nerve trunks from the upper three cervical ganglia, and gives off peripheral branches to the heart, lungs; (2) the **solar** or **celiac** plexus, which receives nerve trunks (splanchnic nerves) from the thoracic portion and gives off terminal branches which form underlying plexuses and innervate the muscles of the intestinal wall, and other organs of the abdominal cavity, bloodvessels, and secreting cells of glands; (3) the **hypogastric** plexus, which receives branches from the lumbar and sacral

FIG. 137

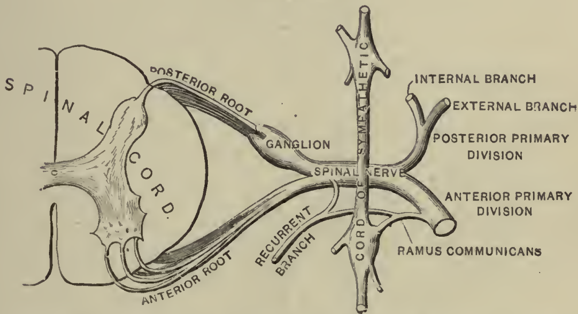


The sympathetic nerve system.

portion of the cord and distributes branches to the bladder, rectum, organs of reproduction, etc.

There are other ganglia situated in the bony cavities of the face and skull, and portions of the neck and face, which, on the one hand, are in intimate relation with the cerebrospinal system through branches of **communication** received from the cranial nerves, and, on the other hand, give off branches of distribution to the salivary glands, organs of special sense, particu-

Fig. 138



Plan of the constitution of a spinal nerve. (W. Keiller, in Gerrish's Text-book of Anatomy.)

larly nerves from the ciliary ganglion which controls the regulation of the pupil in regard to the admission of light to the retina.

The Connections of the Sympathetic Ganglia with the Spinal Nerves.—The spinal nerves as they leave the foramen between the vertebra are connected to the ganglia by two small nerves called the **rami communicantes.** One branch is white, the other gray. The white rami are found connecting only the spinal nerves included between the first thoracic nerve and the second or third lumbar and the corresponding ganglia. The gray rami are found passing from each one of the ganglia to the corresponding spinal nerve.

The White Rami.—These contain medullated nerve fibers and have their origin in the ganglia of the cord; and other axones also pass from the ganglia forward by way of the rami to the spinal nerve, and terminate through these nerves, to be distributed to the plexuses in the abdominal and thoracic organs.

The Gray Rami.—These are composed of non-medullated nerve fibers; the axones arise in the nerve cells of the central ganglia and pass to the spinal nerve, wherein they are conveyed to the structure in the skin, non-striated muscles of bloodvessels and the hair follicles, also the epithelial cells of the glands. The foregoing description of the white and gray rami show the course of the efferent nerves from the nerve-cells situated in the lateral and anterior portion of the gray matter in the thoracic and lumbar regions of the spinal cord. The axones from these nerve cells leave the spinal cord by way of the anterior root, at the point where the anterior and posterior roots join to form the common trunk of the spinal nerve, to pass to the ganglion wherein the axones are in relation with other neurones.

The afferent sympathetic fibers give rise to pain and other reflex phenomena when stimulated. They reach the spinal centres by passing through the gray rami to the ganglion on the posterior root, where they communicate with other neurones and are conveyed by their axones to the cells in the posterior horns of the spinal cord; some fibers pass into and through the white rami.

The Functions of the Sympathetic System.—It is a connecting link between the cerebrospinal system and the tissues of the body which carry on the involuntary functions. By the connection of the ganglion with each other, and the spinal cord and brain at different levels, through the rami communicantes, one can easily understand the numbers of different routes by which impulses can pass, thus influencing

several different structures by reflex actions taking place between these groups of ganglia and their associated neurones. The sympathetic nerves convey nerve impulses which, in response to stimuli transmitted to them through ganglia and their connections with the cerebrospinal system, control the secretion of the glands; others control the caliber of the bloodvessels by vasoconstrictor and vasodilator nerves, passing to the muscular coat of the vessel, the former regulating the contraction, the latter the dilatation of the bloodvessels; others regulate the force and rate of the heart muscle—called cardio-accelerator, which increase the action, and cardio-inhibitor, which decrease it. Other nerves convey impulses to the organs of special sense, as those regulating the size of the pupil. Emotional states, either of an exciting or depressing nature, influence the activity of the sympathetic system by impulses transmitted through the spinal cord and ganglia from the brain, which reach the organs of digestion, etc., by reflex pathways established between the ganglia and ganglionic plexuses and their secreting cells and bloodvessels.

QUESTIONS

1. Give the divisions of the nerve system.
2. What parts of the nerve system are included under the cerebrospinal system?
3. What is the essential cell structure of all nerve energy and reflex called?
4. Name the protoplasmic processes given off from a neurone.
5. How large are the bodies of nerve cells?
6. Give the classification of neurones as regards their number of processes.
7. Describe a dendrite of a neurone. Do they increase the functionating surface of a neurone?
8. What is the function of the dendrites as regards nerve impulses?
9. Describe an axone or axis-cylinder.
10. How long is an axone?
11. How many axones are given off from a neurone? Name them as to the numbers.
12. What do you understand by tolendria?

13. What is the function of the axones as regards nerve impulses?

14. What do nerve fibres consist of? Name the two varieties.

15. Name the portions of a medullated nerve fiber.

16. Differentiate a medullated from a non-medullated nerve fiber.

17. What do you understand by a node of Ranvier?

18. What is the difference in color between nerve tissue formed of medullated and non-medullated nerve fibers?

19. What forms a nerve? What are the functions of the epineurium, perineurium, endoneurium?

20. Name the two kinds of nerve tissue which support the nerve cells. Are they active as regards the conveyance of nerve impulses?

21. What do you understand by the superficial and deep origin of a nerve?

22. How does an efferent nerve end?

23. How does an afferent nerve end?

24. Name some of the end-organs.

25. Does an efferent nerve convey impulses from the brain and spinal cord to the tissues?

26. In which direction does an afferent nerve convey impulses?

27. How does an efferent nerve end in a skeletal muscle?

28. Describe a nerve plexus.

29. Do the nerve fibers in a plexus maintain the same function as the nerve possesses from its origin?

30. Where are ganglia found? Do their neurones connect with the brain and spinal cord?

31. What is the function of a ganglia as regards the conveyance of nerve impulses?

32. Name the two classifications of nerves concerned in all nerve action or reflex.

33. Describe the physiology of a nerve.

34. What do you understand by the term nerve irritability? Excitability?

35. What is essential to develop or convey nerve impulses in a nerve?

36. Name some special stimuli which develop impulses in the endings of afferent neurones and are conveyed to the brain and spinal cord.

37. How do stimuli arise which develop impulses in the neurones of efferent nerves and are conveyed to muscles, organs, etc.?

38. Name the parts of the nerve system included under the central nerve system.

39. Where is the spinal cord located in the body? How long is it? What is its weight?

40. Name the membranes surrounding the spinal cord.

41. Name the chief columns of the spinal cord. What composes them? Give their general function.

42. Give a brief description of a cross-section of the spinal cord.

43. What is the function of the efferent motor nerve cells in the spinal cord? Afferent sensor nerve cells? Intrinsic nerve cells?

44. How many pairs of spinal nerves are there? Give the number as to the portion of the cord from which they arise.

45. Define a reflex action.
46. What do you understand by sensor conduction as regards the nerve fibers in the spinal cord? Motor conduction?
47. Name the membranes of the brain.
48. What parts of the central nerve system are included under the brain?
49. What are the functions of the medulla oblongata? The pons Varolii?
50. What is the membrane called which separates the cerebrum from the cerebellum?
51. What is the function of the cerebellum?
52. How much does the cerebellum weigh?
53. Name the lobes of the cerebrum.
54. What structure connects the two lateral halves of the brain?
55. Name the ventricles of the brain.
56. Give a brief description of the structure of the cerebrum.
57. What is the weight of the brain in the adult male? Female?
58. Where is the motor area located upon the surface of the cerebrum? Sensor?
59. What parts of the body are controlled from the nerve cells in the motor area?
60. Does the motor area control the limbs of the same side of the body upon which it is located?
61. What are the functions of peripheral nerves?
62. Name the cranial nerves.
63. Name the nerves of smell, sight, taste, and hearing.
64. What nerve supplies all the muscles of expression of the face?
65. What nerve supplies the heart, lungs, through the cardiac and pulmonary plexuses respectively? The liver, stomach, spleen, kidneys?
66. What nerve tissue comprises the sympathetic system? Is it an independent system?
67. What do you understand by the gangliated cord? Is it an independent system?
68. Name the groups of ganglia of the cord.
69. What are the nerves called which connect the spinal nerves with the sympathetic ganglia?
70. Differentiate the nerve fibers in a gray rami from a white rami communicantes.
71. Give a brief description of the functions of the sympathetic system.

CHAPTER XVIII

THE ORGANS OF SPECIAL SENSE

THE nerve system is the means by which the individual is brought into conscious relation with the external world. This consciousness is excited by numerous material impressions which develop nerve impulses in the end-organs of the skin, the tongue, nose, eye, and ear, and are conveyed by afferent nerves to the centres in the cortex of the brain where they awake sensations.

These sensations vary in character. Thus one may feel happy, fatigued, hungry, thirsty, etc., as a result of material changes going on within the body. These are usually spoken of as common or ordinary sensations. The important or special sensations arise as a result of the definite impressions made upon the highly sensitive end-organs, as touch, pain, temperature, pressure, taste, smell, light and its varying qualities, sound and its varying qualities. The physiologic mechanisms underlying these special sensations are spoken of as **tactile,** touch; temperature, pain, **gustatory,** taste; **olfactory,** smell; **optic,** sight; **auditory,** hearing, and are known as the special senses.

The factors necessary to the production of the sensations are: (1) A special physical stimulus; (2) a specialized terminal organ (end-organ); (3) an afferent pathway which conveys the impulse to the centres in the cortex of the brain; (4) a specialized receptive sensor cell in the cortex of the brain.

The **special senses** are five in number: **sense of touch, sense of smell, sense of sight, sense of hearing,** and **sense of taste.**

THE SENSE OF TOUCH

The structures essential to the appreciation of the sense of touch are the skin and mucous membrane of the mouth, etc., the end-organs therein and the afferent nerves which convey the nerve impulses by pathways through the cord and brain to the cells in the tactile area of the cerebrum which are located in the parietal lobes.

The end-organs are the highly specialized organs found not only in the skin, but in other sense organs. They are the sensitive bodies intervening between the surface coming in contact with the skin, etc., and the terminal filaments of afferent nerves. They are more sensitive than the terminals of afferent nerves and receive specific stimuli which excite them to activity; and they in turn transmit the impulses to the afferent nerves. However, these end-organs are usually spoken of as the terminations of afferent nerves.

Classification of End-organs.—(1) **Free Endings.**—Club-shaped processes found in and among the cells of the epidermis (upper layer of skin); they are terminations of minute fibers of afferent nerves.

2. **Tactile Cells.**—They are oval, nucleated bodies found in the deep layer of the epidermis. They are embraced by a crescentic-shaped body (tactile disk) which is directly connected with the afferent nerve.

3. **The Corpuscles of Meissner and Wagner.**—These are found in the papillæ of the derma (deep layer of skin), especially in the palm of the hand and finger tips. They are bodies which consist of numbers of tactile disks surrounded by connective tissue and are in connection with the terminals of afferent nerves.

4. **Hair Wreaths.**—They are minute nerve fibers, consisting of a whole axis-cylinder, which surround the hair follicle just beneath the opening of the seba-

ceous glands. They are arranged in the form of a wreath.

5. **Corpuscles of Vater or Pacini.**—They are oval-shaped structures situated along the course of afferent nerves distributed to the skin on the palms of the hands and soles of the feet, external genital organs, joints, etc. They consist, when examined under the microscope, of bulbs composed of granular protoplasm surrounded by layers of connective tissue, and are joined by the axis-cylinder of the afferent nerve.

The **sense of touch** is the sensation conveyed to the brain by an object we touch coming in contact with the end-organs in the skin and mucous membranes. By this sense we are enabled to touch and be touched by objects and determine their size and weight; quality, whether hard or soft, rough or smooth, sharp or dull, etc.; also the temperature of a body or surface coming in contact with the skin and mucous membranes, whether it is hot or cold.

The Skin.—The skin possesses (1) touch sense and (2) temperature sense. The touch sense is subdivided into (*a*) pressure sense and (*b*) place sense.

The **touch sense** is stimulated by mechanical pressure coming in contact with the end-organs in the skin and mucous membrane.

Touch Spots.—The areas of the skin and membrane, which when stimulated by an object, as pin, knife, etc., give rise to the sensation of touch, are not general throughout the surface of the skin, but are localized spots in the skin (these areas are called **touch spots**) with intervals which are insensitive to stimuli.

The greater number of touch spots in a given area the greater is the acuteness of the touch. These spots are more numerous in the hands and in the neighborhood of hair follicles. The skin of the index finger

over the last phalanx is particularly well supplied with touch spots localized in the corpuscles of Meissner, thus rendering the tip of the finger more acute in the sense of touch. It must be remembered that when the pressure and temperature (extremes of heat or cold) of an object are too severe the sense of touch and temperature is lost in the sense of **pain.** The sense of touch is replaced by the sense of pain when the skin is bruised or burned, so that the epidermis is destroyed, leaving the nerves too exposed.

The **sense of pressure** is the variety of the touch sense which is based on the fact that, when pressure is brought to bear along with touching an object, the pressure of the object coming in contact with the skin must reach a certain intensity before the sensation of weight will be appreciated, and permit the individual to determine the amount of the pressure, and gauge the comparative pressure of low weights.

The Sense of Place.—Is based on the fact that when a stimulus touches any portion of the skin the sensation caused thereby is, under normal conditions, always referred to the place stimulated. This is always the case, whether the place of stimulation is at two points near or distant from each other on the same side of the body, or the corresponding place on the opposite side. These areas for the localization of sensations are usually arranged in circles throughout the surface of the skin.

The Temperature Sense.—This is supposed to be due to the presence in the skin of special nerve-endings which give rise to sensations of heat and cold, and are different from each other, as well as from those end-organs which give rise to sensations of touch. It has been proved by investigation that throughout the surface of the skin there are spots, called heat and cold spots, which if stimulated give rise to sensations of heat and cold. Each spot responds to only one kind of stimulus, thus a warm object applied to the

skin will only affect the heat spots, and give rise to the sensation of warmth, and the application of a cold one will only influence the cold spots and create a sensation of coldness. The specific physiologic stimuli to the end-organs controlling the temperature sense are termed **thermic vibrations.**

The muscle sense is a series of specific sensations arising as a result of the activities of the muscles of the body or its individual parts of which we are conscious. They are called muscle sensations and are evoked in response to nerve impulses developed in the end-organs in the muscles and tendons, and conveyed by afferent nerves and their connections with nerve cells in the brain.

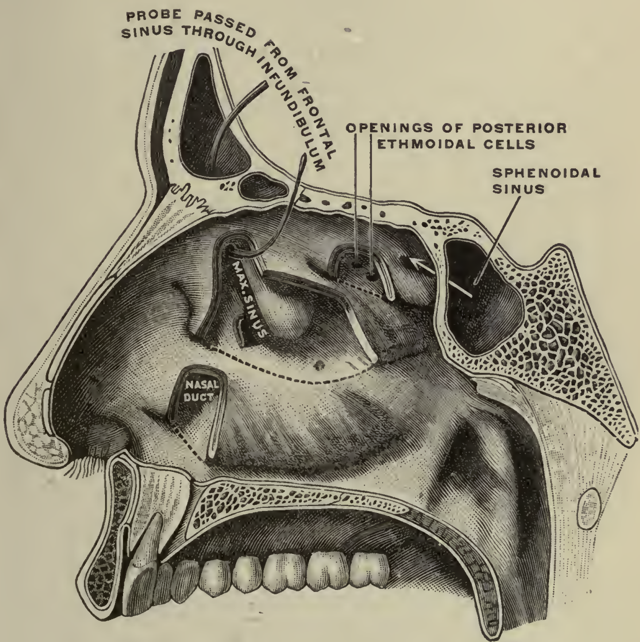
By the consciousness of these sensations we are able to perceive (1) the duration and direction of both passive and active movements of the body; (2) to perceive the resistance offered to movements by external bodies; (3) and to perceive the posture of the body or its individual parts.

THE ANATOMY AND PHYSIOLOGY OF THE STRUCTURES CONCERNED IN THE SENSE OF SMELL

The structures essential to the sense of smell are the nasal fossæ, the olfactory nerve filaments lying within the mucous membrane, and the olfactory tracts which are collections of nerve fibers formed into large nerve trunks and the latter ending in the nerve cells in the uncinate convolutions of the cerebrum (area of sense of smell). Matter in the gaseous or volatile state is the means whereby the peripheral nerves are stimulated, in which are developed nerve impulses, transmitted to the cortex, where they give rise to sensations of odor.

The Nasal Fossæ or Cavities.—These are two bony cavities separated by a vertical wall, formed by the perpendicular plate of the ethmoid, the vomer, and the triangular cartilage. The bony walls are lined with mucous membrane. On the outer wall

FIG. 139



External wall of right nasal fossa, parts of the turbinates having been cut away to show the orifices of the sinuses which open into the meatuses. (Testut.)

each cavity communicates by means of foramen and fissures with the sphenoid, frontal sinuses, the antrum of Highmore, and ethmoid cells, and receives on its floor the opening of the tear-duct from the

lacrymal sac in the inner angle of the eye. By means of this duct the tears pass from the conjunctiva to the nasal cavity. The mucous membrane lining the walls of the nasal fossæ is divided into an olfactory and respiratory portion; in the former the mucous membrane covers the superior turbinated bone and upper part of the septum; it consists of a neuro-epithelium; the respiratory portion is the term given to the remaining portion of the membrane covering the fossa. The membrane lining the nasal cavities is continued through the foramen and fissures leading from it into the sphenoidal and ethmoidal cells, frontal sinuses, antrum of Highmore, and pharynx.

The entrance to the nasal cavities is called the anterior nares; the back of the nasal cavities open into the pharynx and is called the posterior nares or choanæ.

The End-organs.—The end-organs which receive the stimuli that give rise to sensations of odor consist of olfactory and sustentacular cells which rest upon a basement membrane, making up the olfactory portion of the mucous membrane.

Olfactory sensations are classified into agreeable and disagreeable, depending upon the sensations they create in the individual.

THE ANATOMY AND PHYSIOLOGY OF THE STRUCTURES CONCERNED IN THE SENSE OF SIGHT

The Eye.—The eye-ball lies in the fat of the orbit, surrounded by a tunic of fascia, the *capsule of Tenon.* It is composed of segments of two spheres, an anterior smaller and a posterior larger, the junction of the sclerotic and cornea indicating their limits. It measures one inch transversely and vertically, and somewhat less

from before backward. Behind it receives the optic nerve (the nerve of the sense of sight), and in front are the eyelids, eyebrows, etc., which comprise the so-called appendages of the eye.

The Appendages of the Eye.—These include the eyebrows, eyelids, conjunctiva, the lacrymal gland and sac, and the nasal duct. The last three belong to the "lacrymal apparatus."

The *eyebrows* (supercilia) are two prominent tracts of skin above the orbit, covered by thick hairs. They are connected with the orbicularis, palpebrarum corrugator supercilii, and occipitofrontalis muscles.

The *lids* (palpebræ) protect the eyeball. Each is composed of thin skin, areolar tissue, muscular fibers, the tarsal cartilage and ligament, Meibomian glands, and conjunctiva; the upper lid, which is also the more movable, contains, in addition, the aponeurosis of the levator palpebræ muscle.

The lids are separated, when opened, by a space, the fissura palpebrarum, and are united at the angles (canthi). The outer angle is sharp, and the inner is more obtuse. At the inner angle on each lid is found the lacrymal tubercle, pierced by the punctum lacrymale, the upper opening of the lacrymal canal.

The *tarsal cartilages* (tarsi) are two plates of dense fibrous tissue, one in each lid.

The *tendo oculi* or palpebrarum is Y-shaped. The stem is attached to the nasal process of the superior maxilla, and each arm to one of the tarsal cartilages.

The *palpebral ligament* is a fibrous membrane attached to the tarsal cartilages and to the corresponding margin of the orbit.

The *Meibomian glands* (sebaceous) lie on the inner surface of the lids, between the tarsal cartilages and the mucous membrane. In the upper lid there are about thirty; in the lower, fewer.

The *lashes* (cilia) are short, thick hairs forming a double row on the free margin of each lid. Above they are longer and more numerous. They protect the eyes from dust, etc.

The *conjunctiva* is the mucous membrane of the eye. The *palpebral* portion is very thick and vascular, and forms at the inner canthus a fold known as the plica semilunaris. The *ocular* portion is loosely connected to the sclerotic coat, but over the cornea consists only of the conjunctival epithelium.

The Lacrymal Apparatus.—This includes the gland, the two canals, the sac, and the nasal duct.

The *gland* is about the size and shape of a small almond, and lies in a depression in the orbital plate of the frontal bone just inside the external angular process. Its **ducts,** ten or more in number, run beneath the conjunctiva and open separately at the outer part of the fornix.

The *lacrymal canals* commence by small orifices, the puncta, on the margin of each lid, and empty close together into the sac.

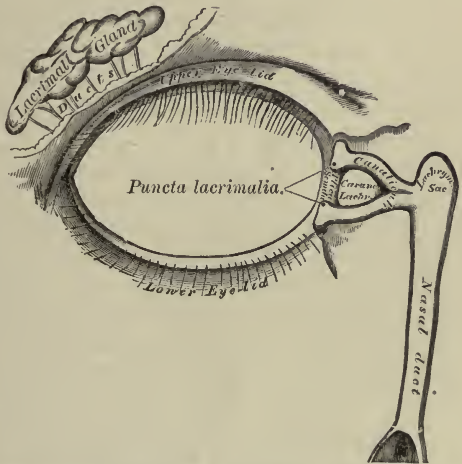
The *lacrymal sac* is the upper dilated part of the nasal duct, and lies in a depression formed by the lacrymal and superior maxillary bones. (See Fig. 140, page 399.)

The *nasal duct* is contained in a canal formed by the superior maxilla, lacrymal, and inferior turbinated bones, and runs from the lacrymal sac to the inferior meatus, beneath the inferior turbinate bone in the nasal cavity. It is lined by a mucous membrane continuous with the conjunctiva.

The secretion from the lacrymal glands is a clear fluid termed the tears, which is secreted by cells of the gland due to sensor nerve fibers from the fifth nerve, sending out impulses in response to reflex stimuli, irritating the afferent nerves in the conjunctiva, as foreign bodies in the eye, etc.; also by

sympathetic impulses conveyed to the secreting cells by way of the sympathetic filaments from the sympathetic system in response to emotional states from the brain centres. The tears consist of water and inorganic salts. The secretion leaves the gland by way of seven or eight ducts and bathes the corneal surface of the eye during the act of winking, thus moistening the eye and removing foreign bodies. It then passes into the lacrymal duct to drain into the

Fig. 140



The lacrymal apparatus. (Gray.)

nasal cavity. An excess secretion, as is observed in weeping, or due to a foreign body in the conjunctiva, passes over the lower lid and drains down the cheek, as well as the nasal cavity.

The Eye-ball.—This consists of three coats enclosing the refractive media or humors. They are the sclerotic and cornea outside, the retina internally, and the choroid between the sclerotic and retina.

The **sclerotic coat** is a dense fibrous membrane, white

and smooth externally, excepting where it receives the insertion of the recti and obliqui muscles. It covers the posterior five-sixths of the eye-ball. Behind it receives the optic nerve at a point just internal to the centre, the fibrous sheath of the former being continuous with the sclerotic.

The **cornea** forms the anterior sixth of the external coat. It is transparent and projecting, and nearly an arc of a true sphere, the anterior surface being convex and the posterior surface concave.

The **choroid** or **intermediate coat** is continued into the cornea. It is a chocolate-colored, vascular structure lying between the sclerotic and retina and investing the posterior five-sixths of the eye-ball, blending in front with the iris after forming a number of folds, the ciliary processes.

The *ciliary muscle* is a circular plane of unstriped muscle placed between the choroid and sclerotic at its anterior part. It consists of circular and radiating fibers. This muscle aids in contracting and dilating the size of the pupil in response to nerve stimuli, and under normal conditions regulates the amount of light entering the chamber of the eye.

The *iris* gives to the eye its color (depending on the pigment present). It is a thin, contractile, circular membrane presenting, at about its centre, a circular aperture, the **pupil.** It is suspended in the aqueous humor behind the cornea and in front of the lens.

The arteries are supplied from the long and anterior ciliary. The nerves are branches of the lenticular ganglion and the long ciliary from the nasal branch of the ophthalmic. They form a plexus around the circumference of the iris, and end in the muscular fibers and in a network on the front of the iris. The nerves to the circular fibers come from the motor oculi; those to the radiating, from the sympathetic.

The Vitreous Humor.—It is a transparent, gelatinous fluid enclosed in a transparent membrane, the *hyaloid*, and fills about four-fifths of the eye-ball. In front it is hollowed out to receive the lens and its capsule, being adherent to the back of the latter. (See Fig. 141, page 402.)

The Crystalline Lens.—This is a solid, transparent, biconvex body which lies, enclosed in its capsule, in front of the vitreous and behind the iris. The greater convexity is behind.

The *capsule* is an elastic, transparent, structureless membrane, in contact anteriorly with the iris and held in place by the *suspensory ligament.*

The *suspensory ligament* is a thin, transparent membrane placed between the vitreous humor and the ciliary processes, and presents externally a number of folds which receive those of the ciliary processes.

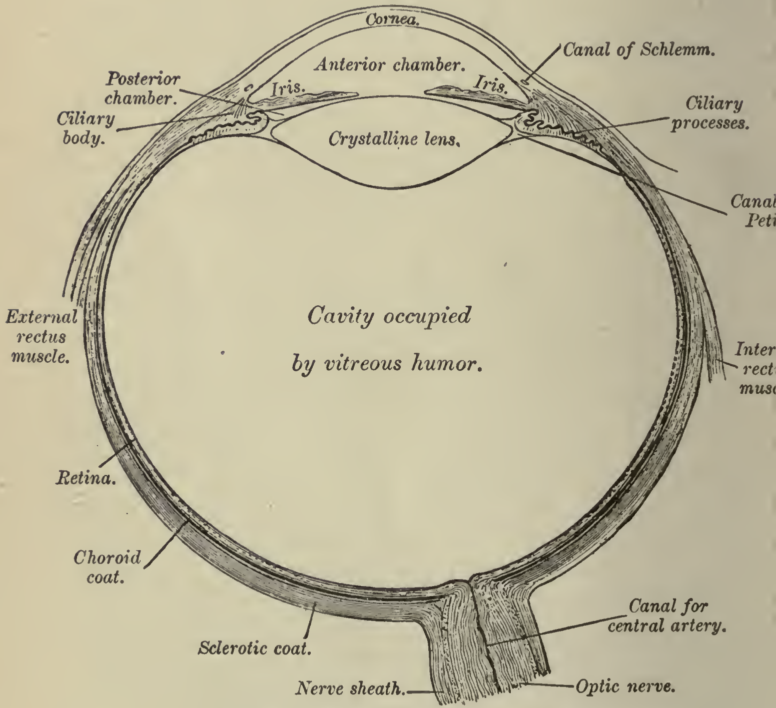
The Aqueous Humor.—This is the fluid which fills the space between the suspensory ligament and capsule behind and the cornea in front. That part of this space which lies in front of the iris is called the *anterior chamber;* the part behind the iris is the *posterior chamber.* The latter is really only the small interval between the iris, suspensory ligament, and ciliary processes.

The *ciliary processes,* seventy or more in number, consist of a circle of folds or thickenings of the choroid received into pits in the vitreous and suspensory ligament of the lens. They are divided into a larger and a smaller set, the former being about one-tenth inch in length. Their inner surface is covered by the layer of hexagonal, pigmented cells in the retina.

The Retina.—This is a delicate nervous membrane on which the image of perceived objects is formed. It lies between the choroid and the hyaloid membrane of the vitreous humor, and is composed of ten layers of cells. Behind, the optic nerve expands into it, and in front it

terminates in a dentated margin, the *ora serrata,* at the outer edge of the ciliary processes. It then sends off a thin, non-nervous membrane, the pars ciliaris retinæ, to the tips of the ciliary processes. The inner surface of the retina presents at its centre an elliptical

Fig. 141



A horizontal section of the eye-ball. (Allen.)

spot about $\frac{1}{20}$ inch across, the *macula lutea.* In the centre of this spot is a depression, the *fovea centralis,* which, on account of the extreme thinness of the retina, shows the pigmentary layer of the choroid, and hence

presents the appearance of a foramen. About $\frac{1}{10}$ inch to the inner side of the yellow spot is the *porus opticus,* at which point the optic nerve enters, the nervous matter being heaped up here so as to form the *colliculus.*

Observed under the microscope the retina consists of cell elements arranged in layers as follows:

1. The layer of pigment cells.
2. The layer of rods and cones, or Jacobsen's layer.
3. The external limiting membrane.
4. The outer nuclear or granular layer.
5. The outer molecular or reticular layer.
6. The inner nuclear or granular layer.
7. The inner molecular or reticular layer.
8. The layer of ganglion cells.
9. The layer of nerve fibers.

The layers in the retina are held together, except the layer of rods, and cones, by a fine net-work of neuroglia, called the fibers of Müller.

The Function of the Retina.—The rods and cones are the most important layer of cell elements in the retina as necessary to vision. This layer possesses the property of receiving light and color stimuli which are transformed into energy that arouses nerve impulses in the fibers of the optic nerve and the latter convey them to the centre of vision in the cerebrum (cuneus) and we are conscious of external objects with their combined colors, etc., through the sense of sight. A ray of light passes through the pupil, crystalline lens, and vitreous humor, to be thrown upon the retina, when it passes through all the layers of the retina and is stopped only upon reaching the pigmentary epithelium in which the rods and cones are embedded. Just how light and color stimuli create nerve impulses is not exactly understood. It is supposed to be due to ether vibrations being transformed into heat, which excites the rods and cones,

and nerve impulses are developed which are conveyed to the brain.

When one becomes conscious of seeing an object, it is due to the fact that an image has been formed by the rays of light passing through the pupil and coming in contact with complex structures which are termed the **refracting apparatus**, which consists of the cornea, aqueous humor, crystalline lens, and vitreous humor. The rays of light must pass through these structures, and as they pass from one to the other they are changed in direction by their surfaces and are narrowed to a single point of focus on the retina. Thus if the rays of light coming from various directions and distances were not focussed, the same as an object on the lens of a camera, they would simply be thrown on the retina and create the sensation of diffused light rays, and form an indistinct image on the retina.

Accommodation.—This is the term expressing the power possessed by the eye of adjusting itself to vision at different distances; or the power of focussing rays of light on the retina, which come from different distances at different times (Brubaker's *Physiology*). In other words, the eye cannot see two different objects at different distances, and both be distinctly seen. If the eye looks at the distant object the near object is not clear, and then when the eye focusses on the near object the distant one is indistinct.

Accommodation is regulated mainly by the changes in the shape of the lens produced by the action of the ciliary muscle; and the pupil becoming decreased or increased in circumference.

The change in the shape of the lens is the means by which the eye accommodates itself to vision. How this mechanism of accommodation is produced is not definitely settled. However, it is supposed to be due to the anatomic relation between the ciliary

muscle and suspensory ligament. The former is attached to the ligament, and the ligament is the supporting structure of the lens. If the eye is looking at a near object the lens becomes more convex or bulges in front. This is produced by the ciliary muscle contracting and relaxing the ligament which permits the lens to bulge forward and become more convex—due to its elasticity. The nearer an object is to the eye the greater will be the divergence of the rays of light, and as a result the lens becomes more convex in order to converge and focus the rays upon the retina, so that the image will be distinct. If the eye is looking at a distant object the lens is less convex. The further away an object is from the eye, the less divergent will be the rays of light. Thus the lens is not called upon to converge the rays of light as they fall upon the retina to appear distinct, as is the case in looking at a near object. At the same time the pupil also becomes narrowed to prevent an indistinctness of the image by permitting an excess of light rays to pass. These would otherwise be too diffuse, due to the angle at which they enter, to permit of a proper focussing of the image on the retina.

In seeing an object both eyes are involved, and two images, one in each eye, are focussed upon the retina, but there arises only one sensation. This is due to the fact that both eyes converge toward the object seen, and it is focussed as an image upon the foveæ at corresponding points in each retina. When any condition interferes with the proper convergence of the eyes toward an object, double vision occurs, due to the object falling on two different points of the retina.

The function of the iris is to regulate the quantity of light entering the interior of the eye and adjust the rays of light so that the formation and perception of an image shall be distinct.

This diaphragm-like action of the iris is produced by the contraction and relaxation of the muscle fibers contained therein—**sphincter pupillæ** and **dilator pupillæ** muscles. The contraction of the sphincter pupillæ is reflex and is spoken of as the iris reflex.

THE ANATOMY AND PHYSIOLOGY OF THE STRUCTURES CONCERNED IN THE SENSE OF TASTE

The structures concerned in the sense of taste include the tongue and its taste-buds, and the nerves conveying the sensations to the taste centre situated in the fourth temporal convolution of the temporal lobe of the cerebrum, where the nerve impulses give rise to the sensations of taste. The stimuli to create these nerve impulses is matter, organic and inorganic, in a state of solution, as brought about by the actions of mastication and insalivation.

The End-organs or Taste-buds.—They are ovoid bodies embedded in the epithelial cells covering the mucous membrane of the tongue, soft palate, and posterior surface of the epiglottis. Their broadest portion or base rests on the basement membrane and the apex reaches the surface of the epithelial cells, when it opens by means of a narrow funnel-shaped opening called the **taste-pore**. The wall of the taste-buds consists of long, slender, epithelial cells, within which are narrow spindle-shaped neuro-epithelial cells, which give off hair-like processes which project into the taste-pore; these neuro-epithelial cells connect with the filaments of the glossopharyngeal and chorda tympani nerves (gustatory nerves), and are considered as the peripheral end-organs of the nerves of taste, called taste-buds or taste-beakers.

Sensations of Taste.—It must be remembered the

tongue also possesses the property of conveying impulses which give rise to sensations of touch and temperature, and these make the classification of sensations of taste most difficult. However, the tastes have been classified into four primary groups: **bitter, sweet, acid,** or **salt.** The intensity of the sensation of taste produced by any one of these groups, or a combination of them, is dependent upon their concentration; and the extent of the sensation depends on the area affected, or the number of taste-buds coming in contact with them.

THE ANATOMY AND PHYSIOLOGY OF THE STRUCTURES CONCERNED IN THE SENSE OF HEARING

The Ear.—The ear is divided into the external ear, the middle ear or tympanum, and the internal ear or labyrinth.

The External Ear.—This consists of the projecting part, or *pinna,* and the *external auditory canal* and *meatus.* The pinna, or auricle, is ovoid in outline, concave externally, and facing outward and somewhat forward, presenting eminences and depressions, to which various names have been given.

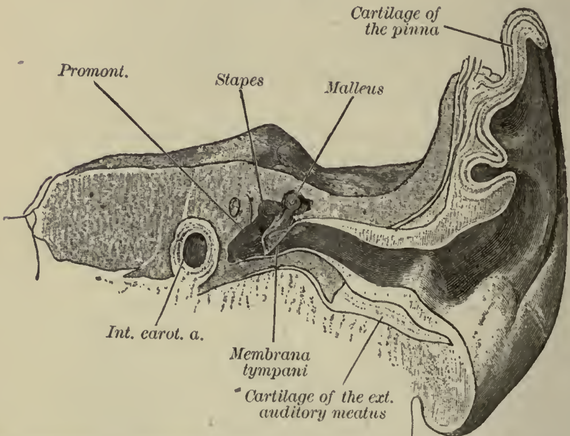
The pinna consists of a plate of yellow fibrocartilage covered by skin and some adipose tissue. It enters also into the formation of the external meatus, being attached to the margins of the external auditory meatus of the temporal bone. The lobule contains only fat and strong fibrous tissue.

The *external auditory canal* is $1\frac{1}{4}$ inches long (adult), and runs from the concha to the membrana tympani. It is directed obliquely forward, inward, and downward, and presents an eminence in the floor of the osseous part, which makes the direction of the canal at first

upward and then downward. It is narrowest at its middle. It opens externally by means of the external auditory meatus.

The Middle Ear or Tympanum.—This is a cavity in the petrous portion of the temporal bone, extending from the membrana tympani to the outer wall of the labyrinth. Its width varies from $\frac{1}{12}$ to $\frac{1}{6}$ inch. It contains the ossicles of the ear, with their ligaments and muscles, and certain nerves. It is filled with air and communicates by means of the Eustachian tube with the nasopharynx.

FIG. 142

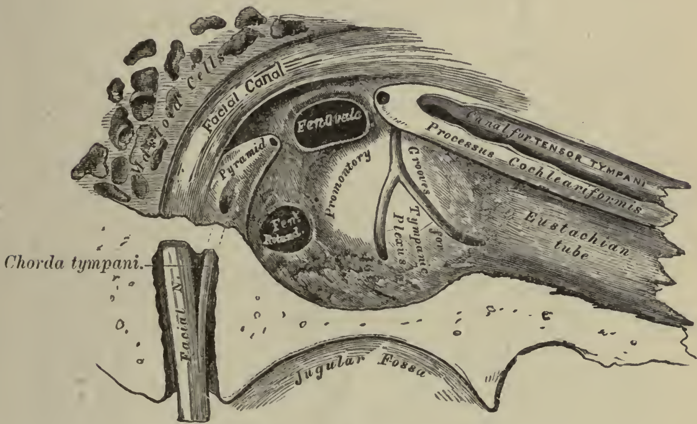


Transverse section of external auditory meatus and tympanum. (Gegenbaur.)

The *membrana tympani* is a thin membrane inserted into a ring of bone at the bottom of the external canal, which is grooved for its reception. It is ovoid in form and directed obliquely downward and inward. On its inner surface is the handle of the malleus, which extends from about the middle of its roof to a little below its centre, covered by mucous membrane, where

it is attached. This process draws the membrane inward, making its outer surface concave and its inner convex. Externally, the membrane is covered with skin, continuous with that of the meatus; internally, with mucous membrane continuous with that of the tympanum; and between these two is a fibrous layer, some of its fibers radiating from the handle of the malleus, others being circular and placed near the circumference.

Fig. 143



View of inner wall of tympanum. (Gray.)

The *inner wall* of the tympanum is vertical and uneven. It presents the following: (*a*) The *fenestra ovalis,* leading into the vestibule, and occupied in the recent state by the base of the stapes and its annular ligament. (*b*) *Fenestra rotunda,* in a conical fossa leading into the cochlea, a rounded eminence. (*c*) The *promontory,* separating it from the preceding. It is closed, in the recent state, by the *membrana tympani secundaria.* This is composed of three layers, and is concave toward the tympanum.

The *posterior wall* of the tympanum presents above one large and several small apertures leading to the *mastoid cells*.

The *anterior extremity* opens into two canals separated by a process of bone, the *processus cochleariformis*. The upper of these canals is the smaller and transmits the tensor tympani; the lower contains the Eustachian tube, an osseocartilaginous passage $1\frac{1}{2}$ inches long, leading to the pharynx. Both of these canals run in a direction downward, forward, and inward.

The osseous part of the Eustachian tube is $\frac{1}{2}$ inch long, and to its lower end is attached the triangular piece of fibrocartilage forming the remainder of the tube. The edges of the cartilage are now in contact, but are joined by fibrous tissue. The tube is wide at its lower extremity, and opens at the upper and lateral part of the pharynx, above the hard palate and on a line with the lower turbinated bone. It is lined by epithelium continuous with that of the pharynx.

The **ossicles** are three minute movable bones, named the malleus, incus, and stapes. The first is attached to the membrana tympani; the second is between the other two; the last named is attached to the fenestra ovalis of the cochlea.

THE MUSCLES OF THE MIDDLE EAR.—The **tensor tympani** runs in the canal previously mentioned. Arising from the under surface of the petrous portion, the cartilage of the Eustachian tube, and the margins of its own canal, its tendon is reflected over the processus cochleariformis and is inserted into the handle of the malleus near its root. It pulls on the malleus, thus drawing inward and making tense the membrana tympani. Its *nerve* comes from the optic ganglion.

The **stapedius muscle** arises from the sides of its containing cavity within the pyramid, and, emerging from the apex, is inserted into the neck of the stapes. It

draws the head of the stapes backward, thus pressing the base against the fenestra ovalis and compressing the contents of the vestibule. Its *nerve* is the tympanic branch of the facial.

The Internal Ear.—This is the essential part of the hearing apparatus, since here the auditory nerve is distributed. It is contained in a cavity in the petrous bone, and is made up of the osseous labyrinth and the membranous labyrinth.

The **osseous labyrinth** contains the *membranous* labyrinth, and is divided into three parts, the vestibule, semicircular canals, and cochlea. It communicates in the dry state with the tympanum by means of the fenestræ. Between the osseous and membranous labyrinth is a space occupied by a clear fluid, the perilymph, and within the membranous labyrinth is the endolymph.

The **vestibule** is the central cavity lying between the cochlea in front and the semicircular canal behind, the tympanum being external. Its *outer* or tympanic *wall* presents the *fenestra ovalis.*

Its *inner wall* has in front a depression, the *fovea hemispherica,* pierced by several minute holes for the auditory filaments, and behind this a ridge, the *crista vestibuli.* Behind this ridge is the opening of the *aqueductus vestibuli.* In the *roof* is a depression, the *fovea hemielliptica.*

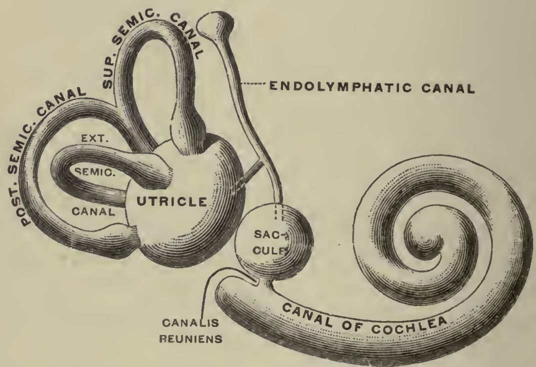
Behind, the vestibule presents five foramina leading into the semicircular canals, and *in front* a larger foramen leading into the scala vestibuli of the cochlea.

The **semicircular canals** are three bony tubes of unequal length lying above and behind the vestibule, each forming about two-thirds of a circle. Their general diameter is $\frac{1}{20}$ inch, but at one end is a dilatation, the ampulla, $\frac{1}{10}$ inch in diameter. They empty into the vestibule by five apertures, in one of which two tubes join.

The **cochlea** resembles a snail shell. Its apex looks forward and outward, and its base toward the internal auditory meatus. Within is a centre piece, the *modiolus* or *columella,* around which the canal runs spirally for two and one-half turns.

Within the canal, and attached to the modiolus, is the *lamina spiralis.* This plate of bone partially divides the spiral canal into two compartments or scalæ, the division being completed by a membrane

Fig. 144



Membranous labyrinth of the right ear, viewed from the outer side; semidiagrammatic. (Testut.)

which reaches the outer wall of the cochlea. The upper scala is known as the *scala vestibuli;* the lower is the *scala tympani.*

The **membranous labyrinth** is contained within the osseous labyrinth, having a similar form, though smaller and separated from it by the perilymph. It contains the endolymph and receives the distribution of the auditory nerve. In the vestibule it consists of the utricle and the saccule.

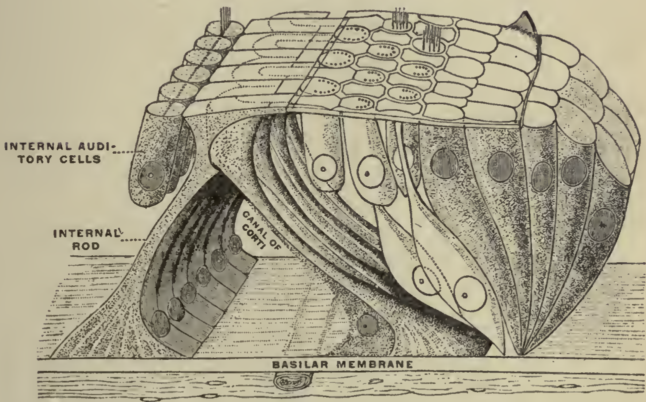
The *membranous semicircular canals* are similar in shape to, but are only from one-fifth to one-third the

diameter of, the bony canals; the ampullæ, however, are relatively large. Two small masses of calcium carbonate are found in the utricle and saccule. They are called the otoliths.

In the cochlea the membranous labyrinth is represented by the *scala media* and the parts therein

THE ORGAN OF CORTI.—It extends the entire length of the cochlea. It consists of two modified epithelial

FIG. 145



Organ of Corti. Diagrammatic view of a small portion. (Testut.)

cells resting upon a basement membrane and joined above to form an arch which encloses a tunnel or canal of Corti; it also consists of a series of columnar epithelial cells with hair-like processes (hair cells) which rest upon and are supported by the rods both on the inner and outer side. Other cells lie adjacent to the hair cells, and are supportive in character; these are called Deiters' cells.

The rods of Corti are very numerous, reaching up into the thousands. The hair-like processes

covering the rods of Corti are bathed by a clear fluid, the endolymph. This fluid comes from the subarachnoid lymph spaces at the base of the brain.

The hair cells resting on the organ of Corti are practically end-organs of the cochlear branch of the auditory nerve. Just how the filaments of this nerve come in direct contact with these cells and develop nerve impulses is not definitely understood.

The Physiology of the Structures Concerned in the Sense of Hearing.—The sense of hearing is based on the functions possessed by the structures within the three portions of the ear, which receive and transmit atmospheric vibrations set up in the external world about us, to the sensitive hair cells of the organ of Corti, where they are taken up and carried back by the fibers of the auditory nerve to the centres in the cerebrum and the brain becomes conscious of the sensations of sound.

Stimuli.—All stimuli which produce the sense of sound must be in a state of motion, and thus create vibrations which are communicated to the air in which they are moving to and for, setting it into waves, called **sound waves.** These sound waves in turn reach the tympanic membrane through the external auditory canal, and set it into vibration; then they are transmitted to the structures of the internal ear by means of the ossicles and structures within the middle ear which convey vibrations to the endolymph in the internal ear and the latter stimulate the hair cells in relation with the organ of Corti. From the latter end-organ they are transmitted to the centres of hearing in the brain through the fibers of the auditory nerve.

Vibrations producing sound waves in the atmosphere are communicated to it by means of the moving to and fro of elastic bodies as tuning forks, rods, strings, membranes, etc.

Sound.—Sounds which arise as the result of impact and transmission of the effects of sound waves are said to possess intensity, pitch, and quality or tone.

Intensity.—When we speak of the intensity of a sound it means the loudness.

Pitch.—Pitch of a sound depends upon the number of vibrations which strike the ear in a unit of time, a second. The greater the number of vibrations the higher the pitch and *vice versa.*

Quality.—Quality of a sound depends upon the form of the vibration. The form of the sound wave in any given instance is the resultant of a combination of a fundamental vibration and certain secondary vibrations of subdivisions of the vibrating body. These secondary vibrations give rise to what is known as overtones. By their union with and modification of the fundamental vibration there is produced a special form of vibration which gives rise not to a simple but to a composite sensation. It is for this reason that the same note of the piano, the violin, and the human voice varies in quality (Brubaker).

QUESTIONS

1. Name some of the ordinary sensations.
2. Name some of the special sensations. How do they arise?
3. Name the special senses.
4. What structures are essential for the appreciation of the sense of touch?
5. Name some of the end-organs concerned in the sense of touch.
6. Where are the corpuscles of Meissner located? Of Vater?
7. What do you understand by the sense of touch?
8. Name the senses possessed by the skin.
9. What does the individual perceive by the muscle sense?
10. What structures are essential to the sense of smell?
11. Bound the nasal fossæ.
12. Name the two portions into which the mucous membrane of the nasal fossæ is divided.
13. What type of epithelium is found in the olfactory portion of the nasal mucous membrane?
14. Name the appendages of the eye.

15. What structures are included under the lacrymal apparatus?
16. How many lacrymal ducts are there and where do they drain?
17. How do the tears reach the nasal cavity?
18. Name the coats of the eye-ball.
19. What muscle controls the diameter of the pupil?
20. What structure contains the pigment which gives the eye its color?
21. Where is the vitreous humor found in the eye? The aqueous? The crystalline lens?
22. Where is the anterior chamber of the eye? The posterior chamber?
23. What is the function of the retina?
24. What nerve expands into the retina and when does the nerve enter it?
25. How many layers of cells in the retina? Which layer of cells is the most important as regards vision?
26. Name the refracting apparatus of the eye.
27. What is accommodation as regards vision? What is the function of the lens in relation to accommodation?
28. What is the function of the iris?
29. Name the structures concerned in the sense of taste.
30. Where are the end-organs or taste-buds located?
31. Name the three divisions of the ear.
32. How long is the external auditory canal? What is its direction?
33. Describe the tympanum or middle ear.
34. Where is the tympanic membrane located? What structure covers its outer and inner surfaces?
35. Through what tube does the tympanic cavity of the ear communicate with the nasopharynx?
36. What structures are included under the term internal ear?
37. What are the divisions of the osseous labyrinth as regard its formation?
38. Where is the membranous labyrinth located. What fluid does it contain.
39. What fluid separates the membranous from the osseous labyrinth?
40. Where is the organ of Corti located?
41. What relation do the hair cells in the organ of Corti bear to the auditory nerve?
42. How many ossicles are there in each middle ear? Name them.
43. In what state must all external stimuli be in to produce the sense of sound.
44. How do vibrating bodies affect the atmospheric air as regards the sense of sound?
45. Give a brief description of how the sound waves are conveyed from the external air to the filaments of the auditory nerve in the organ of Corti.

CHAPTER XIX

ORGANS OF REPRODUCTION

THE EXTERNAL ORGANS OF REPRODUCTION (FEMALE)

The Vulva.—The term *vulva*, or *pudendum*, includes the mons veneris and labia, the nymphæ and clitoris, the hymen or its remains, the meatus urinarius, and the vaginal orifice.

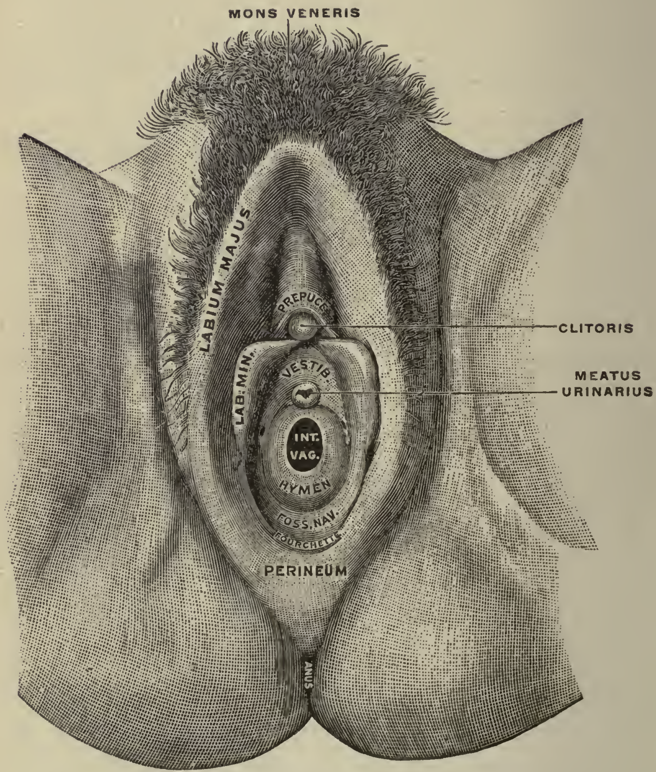
The **mons veneris** is a fatty cushion covering the front of the pubes, and after puberty is plentifully supplied with hairs. Below, it divides into the two **labia majora**, which diminishing in size as they pass downward and backward, unite an inch in front of the anus. The two extremities are joined, and form the anterior and posterior commissures. Between the latter and the anus is the perineum, and just within the posterior commissure is a transverse fold, the fourchette.

The **nymphæ**, or labia minora, smaller than the above, run from the middle of the labia majora upward to the clitoris, each dividing into two folds, the upper pair of which join to form a prepuce for that organ, and the lower two to form its frenum. They are continuous externally with labia majora, internally with the vagina.

The **clitoris** is the opposite of the penis (male), consisting, like it, of two corpora cavernosa united by a septum pectiniforme and prolonged behind into two

crura attached to the rami of the pubis and ischium (bones). It also has a suspensory ligament and a

FIG. 146



Vulva of a virgin. The labia have been widely separated. *Foss. nav.*, fossa navicularis; *Int. vag.*, introitus vaginæ; *Lab. min*, labium minus; *Vestib.*, vestibule. (Testut.)

glans enclosed by the nymphæ. Two erectores clitoridis muscles are attached to the crura. It has no corpus spongiosum nor urethra.

Between the clitoris and the vagina, bounded on each side by the nymphæ, is the **vestibule,** a triangular space, in which, just above the vagina, is the opening of the urethra, one inch below the clitoris.

The **hymen** is a mucous fold which more or less completely occludes the opening of the vagina. It is generally semilunar in form, concave above, or it may be a complete membrane, perforate or imperforate, or it may be absent. It is usually present in a virgin, though its absence does not prove that coitus has been performed.

The **glands of Bartholin,** the analogues of Cowper's glands in the male, are two yellowish bodies on each side of the vaginal opening, each of which discharges by a single duct between the hymen and the nymphæ.

The Urethra.—The *female urethra* is a mucous canal, $1\frac{1}{2}$ inches long, running downward and forward in the anterior vaginal wall from the neck of the bladder to the meatus urinarius and drains the urine from the bladder during micturition, and can be seen as a minute opening just below the clitoris. As in the male, it pierces the triangular ligament, and is surrounded by the compressor urethræ muscle.

The Vagina.—The *vagina* extends from the vulva to the uterus (os uteri), lying behind the bladder and in front of the rectum, and is about 4 inches long on its anterior wall, 5 to $5\frac{1}{2}$ on its posterior, and is directed from the uterus downward and forward.

Above, it embraces the cervix uteri, and its walls are flattened from before backward. *In front* it is in relation with the urethra and base of the bladder; *behind*, it is connected with the anterior wall of the rectum by its lower three-fourths, the cul-de-sac of peritoneum (Douglas') separating them in the upper fourth; *laterally*, the broad ligaments are attached above, and the levatores ani below, as well as the rectovesical fascia.

Its inner surface presents a mesial ridge or raphe on the front and back walls, the columnæ rugarum, and from them on both sides run out transverse folds or rugæ.

THE INTERNAL ORGANS OF REPRODUCTION (FEMALE)

The internal organs include the uterus, tubes, and ovaries.

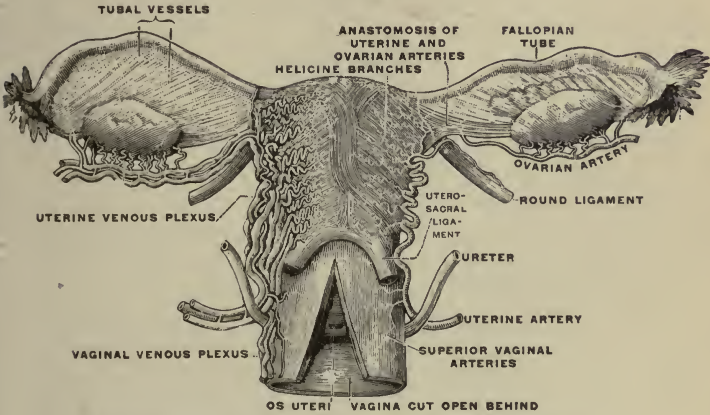
The Uterus.—The **uterus** or **womb** is a hollow muscular organ lying in the pelvis between the bladder and rectum. In the virgin it is pear-shaped, flattened from before backward, its upper end looking forward and upward, its lower downward and backward, forming an angle with the vagina. Above, it is invested by the peritoneum, which covers its body before and behind; it covers also the cervix behind, but in front the peritoneum is reflected on to the bladder before reaching the cervix. The two folds of peritoneum after investing the uterus are applied to each other, reaching across to the lateral pelvic walls forming the broad ligaments.

The uterus is 3 inches long, 2 wide, and 1 thick, and it weighs about 1 ounce. It is divided into a body, fundus, and neck. The **fundus** is the convex part above the entrance of the tubes; the **body** is the part between this and the neck. In front of the Fallopian tubes, at the upper part of the lateral borders, the round ligaments are attached, and below and behind them are the ligaments of the ovaries. The **cervix** is the lower constricted, rounded part, and around it is attached the vagina. At its vaginal end is a round opening, the os uteri.

The **cavity** of the uterus is small; that part within the body is triangular, flattened anteroposteriorly,

and presents at the superior angles the openings of the Fallopian tubes; also, at its junction with the neck it is constricted to form the os internum. The cavity of the cervix is barrel-shaped and flattened anteroposteriorly, presenting on each wall a longitudinal column sending off oblique rugæ on each side; hence its name, arbor vitæ uterinus.

Fig. 147



Vessels of the uterus and its appendages, rear view. (Testut.)

The **walls** of the uterus consist of an outer serous coat, an inner mucous, and an intermediate muscular. The muscular coat forms the bulk of the uterus, and consists of bundles and layers of unstriped fibers which interlace, and of some areolar tissue supporting them, and of bloodvessels, lymphatics and nerves.

The **mucous membrane** of the *body* differs from that of the cervix. The former is smooth, reddish, with columnar cells, and presents the ducts of a number of tubular glands which end by blind, sometimes forked, extremities. In the *cervix* it is firmer, and presents

numerous saccular and tubular glands between the rugæ of the arbor vitæ, and below, numerous papillæ.

The **ligaments** of the uterus are the *round* ligaments and several *peritoneal folds,* namely, two each in front, behind, and laterally.

The *round ligaments* are two cord-like bundles of areolar, fibrous, and plain muscular tissue, with vessels and nerves, covered by peritoneum, which run from the upper angle of the uterus to the internal abdominal ring. Each then runs through the corresponding inguinal canal to end in the mons veneris and labia.

The *anterior* or *vesico-uterine ligaments* stretch between the bladder and the uterus; the *posterior,* between the uterus and rectum, hence called the *recto-uterine,* forming a pouch of peritoneum, the cul-de-sac of Douglas.

The two *lateral* or *broad ligaments* pass from the sides of the uterus to the sides of the pelvis, thus dividing the latter into two parts. They are formed by the coalescence of the peritoneal layers investing the anterior and posterior surfaces of the uterus, and contained between the two layers—the Fallopian tube at the upper margin; the round ligament below and in front of the tube; the ovary and its ligament enfolded by the posterior layer; and the uterine bloodvessels, lymphatics, and nerves.

Appendix.—The Function of the Uterus.—The uterus receives and affords a surface for the growth and development of the fecundated ovum and its membranes, which become the embryo, nourished from the placenta (after the third month), and retains it until the fœtus is fully developed (nine months), when, by a contraction of its muscular walls, the offspring is delivered through the vagina.

The Fallopian Tubes.—The **Fallopian tubes** or oviducts run from the upper angles of the uterus toward the sides of the pelvis, and near their termina-

tion bend downward, backward, and inward. They are 3 to 4 inches long, are at first narrow, then enlarge near the extremity (ampulla), and end in a fimbriated margin, one of the fimbriæ being attached to the ovary. The canal is very narrow at the uterine end (ostium uterinum), begins to widen in the outer half to form the ampulla, and at its termination again narrows (ostium abdominale).

The tubes consist of a peritoneal coat, a muscular coat composed of internal circular and external longitudinal fibers, and a mucous coat. The latter is continuous at the inner aspect of the tube with the membrane of the uterus, where it opens; and at the outer extremity is continuous with the peritoneum and communicates with the peritoneal cavity. The epithelium is of the ciliated columnar variety, and is thrown into longitudinal folds, more marked in the outer half of the tube.

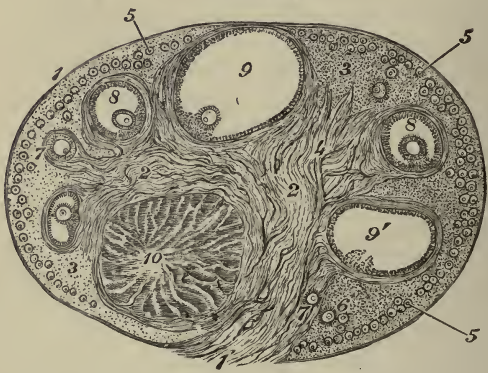
The Ovaries. — The ovaries correspond to the testicles in the male, as far as the sex relation is concerned, and produce the ovum or germ cell. They are flattened, oval bodies, measuring $1\frac{1}{2}$ inches long, $\frac{3}{4}$ inch wide, and $\frac{1}{2}$ inch thick; each weigh 60 to 100 grains. They are located in the abdominal cavity on either side of the uterus, lodged in the folds of peritoneum called the broad ligaments of the uterus. The sides of each one and the convex border are free, while the straight border is attached to the broad ligament and receives the bloodvessels, etc., at this point.

Its outer end is attached to the Fallopian tube by the fimbria ovarica, its inner end to the uterus by the ligament of the ovary, a dense, fibromuscular cord attached to the uterus below and behind to the tube.

The Structure of the Ovary.—It consists of an external thin connective-tissue membrane, and an internal thin connective-tissue stroma, which supports the bloodvessels, nerves, and non-striated muscle fibers, and

contain in its meshes the Graafian follicles. These consist of spheric sacs and are present in large numbers from the time of birth to the period of the menopause (change of life). Each follicle consists of an external investment of fibrous tissue and bloodvessels, and an internal investment of cells, the membrana granulosa. At the lower portion of this membrane there is an accumulation of cells, called the proligerous disk. The cavity of each Graafian follicle contains fluid,

Fig. 148



Section of the ovary: 1. Outer covering. 1′. Attached border. 2. Central stroma. 3. Peripheral stroma. 4. Bloodvessels. 5. Graafian follicles in their earliest stage. 6, 7, 8. More advanced follicles. 9. An almost mature follicle. 9′. Follicle from which the ovum has escaped. 10. Corpus luteum. (After Schron.)

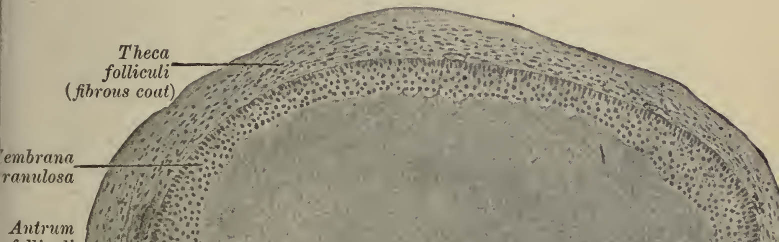
yellowish in color, alkaline, and is composed of albuminous material. ·From the Graafian follicle, and particularly the proligerous disk, the ovum or germ cell is developed.

The Ovum or Germ Cell.—This is a spheric body measuring 0.3 mm. in diameter. It consists of a mass of living protoplasmic material, cytoplasm; a nucleus or **germinal vesicle**, within which is seen a nucleolus or **germinal spot.**

The cytoplasm surrounding the germinal vesicle is granular in appearance, and is called the **vitellus**; the outer margin of the cytoplasm is surrounded by a delicately striated border called the **zona pellucida.**

The ovum is the cell which is fertilized by the spermatozoön of the male and develops into the embryo and its ultimate creation, the human being—the infant.

FIG. 149



Section through a Graafian follicle from an ape's ovary. × 90. (Szymonowicz.)

Ovulation.—This is the term used to describe the process whereby the mature Graafian follicle ruptures and the ovum is forced through the layers of the ovary. When the female reaches the age of puberty (which varies in different races and in certain climates) the Graafian

follicle develops and ripens or matures periodically, about every twenty-eight days. When mature the vesicle ruptures and the ovum and liquid contents of the vesicle are discharged. The ovum is received by the fimbriated extremity of the Fallopian tube, enters its cavity, wherein it is transferred through the tube by the peristaltic action of its muscle fibers, aided by the cilia of the lining epithelial cells, into the body of the uterus, where it is fertilized, when mature, by the spermatozoa—the germ cell of the male. The ovum may be fertilized in the Fallopian tube. The passage of the ovum from the ovary to the uterus occupies approximately four to ten days. The ovum undergoes a succession of changes, particularly the nucleus, after it leaves the ovary before fertilization can occur. (See Maturation, p. 35.)

Corpus luteum is a yellowish body which is present in the ovum following the rupture of the Graafian follicle and the ovum escapes into the oviduct (ovulation). When the follicle ruptures the antrum fills with blood and forms the **corpus hemorrhagicum.** This body becomes organized and the hemoglobin is absorbed, which leaves a yellowish body, due to the presence of many large yellow cells called **lutein cells.** The corpus luteum occurs every twenty-eight days. If fecundation occurs the corpus luteum persists in the ovum as a yellowish body as described above, and persists throughout the term of pregnancy. However, if fecundation does not occur the corpus luteum shortly contracts, becomes whitish and forms the **corpus** albicans.

The latter change is supposed to be due to a fatty degeneration of the lutein cells. The corpus luteum is considered a periodic self-developing gland with an internal secretion. Ovulation and menstruation have a close relationship. Menstruation signifies a frustrated ovulation and the discharge of a hyperemic membrane from the uterus. Rupture of the Graafian

follicle occurs on an average nine days in advance of the bleeding.[1] While the ovum is moving along the tube the transformation of the membrana granulosa, of the ruptured Graafian follicle, to the corpus luteum is taking place. The tenth day before menstruation is the surest time for impregnation.

There are many theories on the above which are not mentioned as they are beyond the scope of this book.

Menstruation.—This is a process characterized by a discharge of blood from the vagina, which takes place periodically, except during pregnancy and lactation, when the mammary glands are secreting milk. It occurs from the time of puberty to the menopause (change of live). Ordinarily it comes on every four weeks and lasts from three to five days. It varies as to frequency and duration in different individuals.

The age at which the menses (periodic sickness) commences, varies in different countries, being earlier in warm and later in cold climates. The average age in a temperate climate is about the fourteenth to fifteenth year.

There have been several theories expressed in regard to the changes taking place in the mucous membrane of the uterus at the time of menstruation. Some authorities claim that the entire mucous membrane of the uterus is broken down and thrown off in the menstrual flow. Again, others claim that there is no destruction of tissue, and the menses results from a thickening of the mucous membrane of the uterus (womb), engorgement of its superficial bloodvessels, followed by the escape of blood, due in part to the rupturing of these vessels, and the passing of blood through the walls of the arteries (diapedesis). Following the period of hemorrhage a certain amount of degeneration of the cells takes place in the mucous

[1] The above facts as per Dr. Miller, Berliner klinische Wochenschrift, May 5, 1913; N. Y. Med. Journal.

membrane of the uterus, which is followed by a period of repair when an entirely new membrane is formed. Thus the changes taking place in the uterus during menstruation last for several days (sixteen) as follows: Five days for engorgement of the membrane, four days for the bleeding or menses proper, and seven days for the repair of the membrane after the bleeding stops.

The **menopause** is the term given to the cessation of the menstrual flow. It occurs usually at about the forty-fifth year. Cases have been reported where it has stopped as early as the twenty-eighth or thirtieth year, and extended on the other extreme to the fiftieth year.

QUESTIONS

1. How long is the female urethra?
2. Where does it open and what organ does it empty during micturition?
3. Name the internal organs of reproduction.
4. Give the location of the uterus. Its dimensions.
5. Name the portions of the uterus.
6. What structures open into the cavity of the uterus at the superior angles?
7. Into what does the cervix of the uterus open?
8. What forms the wall of the uterus?
9. What type of epithelium lines the body of the uterus?
10. Name the ligaments of the uterus.
11. What structures are found between the layers of the broad ligament?
12. How long are the Fallopian tubes?
13. What coats form their walls?
14. Does the Fallopian tube communicate with the cavity of the uterus? The peritoneal cavity?
15. What variety of epithelium is found in the mucous membrane of the Fallopian tube?
16. What cell is produced in the ovary which represents the female portion of reproduction?
17. Where are the ovaries located? Give dimensions, weight.
18. What structure is attached to the outer extremity of the ovary?
19. Describe a Graafian follicle. Give contents.
20. From which group of cells in the Graafian follicle is the ovum or germ cell developed?
21. What must fertilize the ovum to reproduce the offspring?
22. What do you understand by ovulation? How often does it occur?
23. How does a mature ovum reach the cavity of the uterus?

TABLES OF WEIGHTS AND MEASURES

Symbols and Abbreviations for Apothecaries' or Troy Weights

gr., Granum. A grain.
℈, Scrupulus. A scruple, equal to 20 grains.
ʒ, Drachma. A drachm, equal to 60 grains.
℥, Uncia. An ounce, equal to 480 grains.
℔, Libra. A pound of 12 ounces of 480 grains each.

Table of Troy or Apothecaries' Weights

20	grs.	=	1 ℈.
60	grs.	=	1 ʒ or 3 ℈.
8	ʒ	=	1 ℥.
12	℥	=	1 ℔.

Symbols and Abbreviations for Apothecaries' or Wine Measures

gtt, Gutta. A drop.
♏, Minimum. A minim is the sixtieth part of a fluidrachm.
fʒ, Fluidrachma. A fluidrachm is the eighth part of a fluid ounce or 60 minims.
f℥, Fluiduncia. A fluidounce, equal to 480 minims or sixteenth of a pint.
O, Octarius. A pint of 16 fluidounces.
Cong., Congius. A gallon of 8 pints or 128 fluidounces.
ss, means half, as ʒss, ½ drachm.

Table of Wine or Apothecaries' Measures

♏60	=	fʒj.
fʒ 8	=	f℥j or 480 minims.
f℥16	=	Oj.
O2	=	1 quart or f℥32.
O8	=	1 cong. gallon.

1 teaspoonful	=	fʒj.
1 dessertspoonful	=	fʒij.
1 tablespoonful	=	f℥ss or fʒiv.
Wineglass	=	f℥j.
Teacup	=	f℥iv.

GLOSSARY

Abdomen. (From the Latin word abdere, "to hide.") The portion of the body included between the thorax and pelvis, which contains the stomach, liver, spleen, kidneys, etc.

Abducens. A nerve to the external rectus muscle of the eye, which abducts it.

Abduction. (From the Latin word ab, "from;" ducere, "to lead.") The withdrawal of a part from the axis of the body, organ, or limb.

Abductor. Muscles which draw the part away from the axis of the body, organ, or limb.

Abductor Hallucis. Abductor of the big toe. See Hallux.

Abductor Minimi Digiti. Abductor of the little toe or finger.

Abductor Pollicis. Abductor of the thumb. See Pollicis.

Absorption. (From the Latin word absorbere, "to suck in.") The passage from without into the capillary or lymphatic vessels of nutritive or waste materials from the tissues.

Accessorius. (Flexor muscle.) Aids the flexor longus digitorum muscle to contract. The lumbricales are also called accessory muscles.

Accessory. (From the Latin word accessorius.) Aiding in producing some effect, as an auxiliary, to muscles, glands, nerves, etc.

Acetabulum. (From the Latin word acetabulum, "a little cup for holding vinegar [acetum].")

Acid in Reaction. Is a term used to express the response to a certain test (litmus paper), as to the acidity of a clinical solution, secretion, excretion from the body, or any of its organs, membranes, etc.

Acromial (process). Pertaining to the acromion.

Acromion. (From the Greek words meaning summit, shoulder.) The outer extremity of the spine of the scapula.

Adductors. Muscles which draw the part toward the axis of the body, organ, or limb.

Adductor Brevis. The short adductor (thigh).

Adductor Longus. The long adductor (thigh).

Adductor Magnus. The large adductor (thigh).

Adductor Obliquus Hallucis. The oblique adductor of the big toe. See Hallux.

Adductor Obliquus Pollicis. The oblique adductor of the thumb. See Pollicis.

Adductor Transversus Hallucis. The transverse adductor of the big toe.

Adductor Transversus Pollicis. The transverse adductor of the thumb.

Adduction. (From the Latin words ad, "to;" ducere, "to lead.") The drawing of a part toward the axis of the body, organ, or limb.

Adenoid. Resembling a gland, as glandular tissue.

Adipose (Tissue). (From the Latin word adeps, "fat.") Fatty.

Adrenal. (From the Latin words ad, "near to;" ren, "the kidney.") Adjacent to the kidney.

Adventitia. (From the Latin word adventitius, "foreign.") The outer coat of a bloodvessel.

Afferent. (From the Latin word afferens, "carrying to.") Carrying to the centre. Sensor nerves conveying impulses from the periphery to the ganglia of the spinal cord, and to the centres in the brain.

Alkaline in Reaction. Is a term used to express the response to a certain test (litmus-paper), as to the alkalinity of a chemical solution, secretion, or excretion from the body or any of its organs, membranes, etc.

Alveolar. (From the Latin word alveolus, "a small hollow.") Pertaining to an alveolus.

Alveolus (pl. i). A small hollow. As the spaces in the lungs at the end of the bronchioles.

Ameba. (From the Greek word ameibo, "to change.") A colorless, single-celled, jelly-like, protoplasmic organism found in sea and fresh waters, constantly undergoing changes of form and nourishing itself by englobing surrounding objects.

Ameboid. Resembling an ameba in its movements. As a white cell of the blood.

Amphiarthrosis. (Around a joint.) A mixed articulation permitting slight motion.

Ampulla (Vater). (From the Latin word meaning a narrow-necked vessel shaped like a jug, in which the ancient Romans conveyed jellies or ointments). A portion of the membrane of the duodenum where the common bile duct and pancreatic duct open. Ampulla, any space shaped as above.

Amyelinic. Without a myelin sheath.

Amylose. (From the Greek word meaning starch.) Any one of the group of carbohydrates, comprising starch, glycogen, dextrin.

Anabolism. Constructive metabolism. Activity and repair of function by the tissues, opposed to katabolism.

Anastomose. To communicate with each other, as arteries, veins, lymphatics, etc.

Anastomosis. The communication between arteries, veins, and lymphatics within the skin, muscles, organs, etc.

Anatomic. Relating or belonging to anatomy.

Annular (ligament). (From the Latin word annulus, "a ring.") Ring-like. The ligament surrounding the wrist and ankle.

Annulus Ovalis. "The oval ring." The oval margin of the foramen ovale in the interauricular wall of the heart. (Ovalis from the Latin word ovum, "an egg.")

Antebrachium. (From the Latin word ante, "before"; brachium, "arm.") The forearm.

Antecubital. The △ space in front of the elbow-joint.

Anterior. Perforated space. An irregular quadrate space, situated at the inferior surface of the cerebrum, between the olfactory trigone and the optic chiasm and tract.

Antrum (Highmore). A hollow cavity found in each maxilla bone. The antrum: any hollow cavity or space.

Apex. The tip, point, or extremity of anything.

Aponeurosis. A fibrous, membranous expansion of a tendon giving attachment to muscles or serving to enclose and bind down muscles.

Appendicular. (From the Latin word appendicula, "a small appendix. See Appendix.) Pertaining to the extremities of the body.

Appendix (vermiform). (From the Latin word appendere, "to hang upon or to.") An appendage.

Aqueductus. (From the Latin words aqua, "water;" ductus, "a leading.") Any canal for the passage of fluid. Nerves, arteries, etc., in structures of the body.

Aqueous. (From the Latin word aqua, "water.") Watery, as the aqueous humor within the eye-ball.

Arachnoid. Resembling a spider's web. A membrane of the spinal cord and brain between the pia and dura mater.

Arbor Vitæ. (From the Latin words arbor, "a tree;" vitæ, "of life.") The appearance of a structure resembling the evergreen tree; as seen on cutting the cerebellum in a longitudinal section, also the similar appearance of the folds of the mucous membrane of the neck of the uterus.

Areolar. (From the Latin word areola, dim. of area, "an open space.") Relating to areola (pl. æ). Any minute space in a tissue, as seen in cellular or loose connective tissue.

Artefact. (From the Latin words arte, "by art;" factum, "made.") A structure or tissue which has been changed from its natural state. (Can only be seen by the microscope.)

Arteriole. (From the Latin word arteriola, a small artery.) A very small artery continued from the larger arteries and ends in the capillary.

Artery. (From the Greek meaning "to keep air." The ancients always though the arteries contained air.) A closed tube which conveys the blood, propelled by the heart, to all parts of the body and terminates as the arterioles and capillaries.

Arthrosis. (From the Greek meaning "to fasten by a joint.") Articulation or jointing, as the extremities of bones are joined by ligaments.

Articular. (From the Latin word articularis, "of the joint.") Pertaining to an articulation or joint.

Arytenoid. Resembling the mouth of a pitcher.

Asternal. Not connected with the sternum, as the false ribs.

Astragalus. (Named from the Greek meaning a dice, named from the fact that the ancients used the corresponding bones of the sheep as dice.) The ankle bone upon which the tibia rests.

Atlas. The first vertebra of the spinal column articulating with the occipital bone and thus sustaining the globe of the head, whence the name. (Any support or prop is termed an atlas, based on the belief of the ancient Greeks that the gods (Atlantes) bore up the pillars of heaven, which were named after Mount Atlas in Western Africa.)

Atrioventricular. Relating to both the atrium (auricle) and ventricle of the heart.

Atrium. (The forecourt or hall.) That part of the auricle of the heart into which the venous blood is poured.

Auriculoventricular. (From the Latin words auricula, "ear;" ventriculus, "ventricle.") Relating to an auricle and ventricle of the heart.

Axial. (From the Latin word axis, see Axis.) Pertaining to the centre or situated in an axis.

Axilla. The arm-pit.

Axillary. Pertaining to the axilla.

Axis. (From the Latin word axis, "an axletree.") An imaginary line passing through the centre of a body. The second cervical vertebra Arterial axis: A short artery which breaks up into several branches.

Axone or Axis-cylinder. (From the Latin axis, "an axletree.") The essential part of a nerve cell which conducts nerve impulses.

Basilar. Pertaining to the base.

Basilic (vein). (From the Greek meaning royal.) Eminent, illustrious. The large vein on the inner side of the arm.

Biceps (muscle). (From the Latin words bis, "twice;" caput, "head.") Having two heads.

Brachialis Anticus (muscle). In front of the arm.

Brachiocephalic (artery and vein). Pertaining to the arm and head.

Bronchial. Relating to the bronchus.

Bronchiole. (Dim. of bronchus.) One of the smallest subdivisions of a bronchus.

Bronchus (pl. i). (From the Greek meaning windpipe.) One of the primary divisions of the trachea.

Buccal. (From the Latin word bucca, "cheek.") Pertaining to the cheek.

Buccinator (muscle). From the Latin word buccinare, "to blow the trumpet.") So called from its use in blowing the trumpet, etc.

Bursa. (From the Latin word "purse.") A small sac interposed between parts that move upon one another.

Bursal. Pertaining to bursa.

Bifid. (From the Latin words bis, "twice;" findere, "to cleave.") Divided into two parts.

Bipolar. (From the Latin words bi, "two;" polus, a "pole"). Having two poles. Nerve cells having two prolongations of their cell matter are termed bipolar.

Blastodermic Vesicle. Pertains to the blastoderm. (The germinal membrane formed by the cells of the morula or mulberry mass, lying on the internal surface of the vitelline membrane of the impregnated ovum.)

Blastula. The blastodermic vesicle.

Brachial (artery). (From the Latin word brachium, "arm.") Pertaining to the arm. B. artery: continuation of the axillary artery in the arm.

Brachium. (From the Latin word brachium, "arm.") The arm, from the shoulder to elbow.

Calcaneum (bone). (From the Latin word calx, "a heel.") The bone of the heel, also os calcis.

Calices (pl. of Calix). (From the Latin word calix, "a cup or chalice.") Cup-like depressions of the membrane of the pelvis of the

ureter which surround and collect the urine from the papilla of the kidney.

Canaliculus. (From the Latin word canaliculus, "a small channel or canal.") Any one of the minute canals opening into the lacunæ (lakes) of bones.

Cancellous. (From the Latin word cancelli, "lattice-work.") Resembling lattice-work, as the tissue in the articular ends of long bones.

Capillary. (From the Latin word capillus, "a hair.") Hair-like. A minute bloodvessel connecting the arterioles and venules.

Capitellum. (Dim. of the Latin word caput, "a head.") A small head.

Carbon Dioxide. An acid, gaseous product having the composition of one atom of carbon to two of oxygen (CO_2). It is formed in the tissues as a result of metabolism. When inhaled or accumulated in the tissues in excess it will destroy animal life by asphyxiation. It kills by depressing the respiratory centre.

Cardiac. Pertaining to the heart or the cardia of the stomach.

Carpus. The wrist. Eight bones collectively form it.

Cava Vena. (From the Latin words cavus, "a hollow;" vena, "a vein.") The large veins which open and empty venous blood into the right auricle of the heart from the systemic veins.

Cavernous (sinus). (Caverna, a cave.) Having hollow spaces. The venous sinus at the sides of the body of the sphenoid bone. It lodges the carotid artery and its sheath, and nerves to the eye muscles.

Celiac. Pertaining to the belly.

Cellular. (From the Latin word cella, "a cell.") Pertaining to or composed of cells.

Centrifugal. (From the Latin words centrum, "to centre;" fugere, to fly.") Receding from the centre to the periphery. C. nerve: One which conducts impulses from the brain and spinal cord to the periphery.

Centripetal. (From the Latin word centrum, "centre;" petere, "to seek.") Traveling from the periphery toward the centre. C. nerve: One which conveys impulses from the periphery toward the brain and spinal cord.

Cephalic. Pertaining to the head.

Cerebellar. (Dim. of cerebrum.) Pertaining to the cerebellum.

Cerebellum. (Dim. of cerebrum.) The lower part of the brain lying below the cerebrum and above the pons and medulla.

Cerebral. Pertaining to the cerebrum.

Cerebrum. (From the Latin word cerebrum, "brain.") The chief portion of the brain.

Cervical. (From the Latin word cervix, "a neck.") Pertaining to the neck—of the body, organ, etc.

Cervix. A neck, or constricted portion.

Chemic or Chemical. Of or pertaining to chemistry.

Chiasm (optic). (From the Greek meaning "to make a cross, as an X.") The optic commissure, where the fibers of the optic nerves meet and cross to pass to the optic tracts.

Chondroblast. A cell of developing cartilage.

Chordæ Tendineæ. Tendinous strings, which are attached by their two ends to the papillary muscles and margins of the auriculo-ventricular valves in the ventricles of the heart.

Chromatin. (From the Greek word meaning color.) The portion of the protoplasm of a cell which takes the stain; forming a delicate net-work of fibrils permeating the achromatin of a cell. Achromatin: The opposite of chromatin.

Chyle. The milk-white fluid absorbed by the lacteals during digestion.

Chyme. Food that has undergone gastric digestion and has not been acted upon by the bile, pancreatic, and intestinal secretions.

Cilia. (From the Latin word cilium, "an eyelash.") The eyelashes. The hair-like appendages of certain epithelial cells, the function of which is to propel fluid or secretion.

Ciliary. Pertaining to the eyclash. Relating to ciliary movement.

Ciliated. Having cilia.

Circumduction. (From the Latin words circum, "around;" ducere, "to lead.") The movement of a limb in such a manner that its extremity describes a circle, the nearest end being fixed.

Clavicle. (From the Latin word clavus, "a key.") The collar-bone

Clinoid. (From the Greek meaning beet-like.) Resembling a beet. The clinoid processes of the sphenoid bone.

Coagulation. (From the Latin word coagulatio, "a clotting.") The formation of a clot as in blood or milk.

Coaptation. The adjustment of parts to each other.

Coccyx. (From the Greek word meaning a cuckoo, resembling the bill.) The last bone of the vertebral column.

Cochlea. The cavity of the internal ear, which resembles a snail shell.

Cœliac. (See Celiac.)

Coitus. (From the Latin word coitio, "a going together.") The act of sexual connection.

Collateral. (From the Latin words con, "together;" lateralis, "of the side.") Accessory or secondary.

Columnæ Carneæ (heart). (Lt., the fleshy columns.) The muscular columns projecting from the inner surface of the ventricles of the heart.

Columnæ Rugarum (vagina). (From the Latin word columnæ, "columns;" rugarum, "of the folds or ridges.") The columns of ridges.

Commissure. (From the Latin words com, "together;" mittere, "to send.") That which unites two parts.

Compressor Narium Minor. The small compressor of the nostrils.

Compressor Nasi. The compressor of the nose.

Concave. (From the Latin words con, "together;" cavus, "hollow.") Hollow, incurved, as the inner surface of a hollow sphere.

Condyle. (From the Greek word meaning a knuckle). Any rounded eminence such as occurs in the joints or parts of many of the bones.

Condyloid. Resembling a condyle.

Connective. To connect; as C. tissue.

Contiguous. (From the Latin word contiguus from the verb contingere, "to touch;" as it were, on all sides.) In actual or close contact; touching; adjacent

Conus Arteriosus (heart). From the Latin word conus, "a cone.") The arterial cone. The cone-shaped eminence of the right ventricle of the heart, whence arises the pulmonary artery.

Convex. (From the Latin words com, "together," vehere "to carry.") Elevated and regularly rounded.

Coracoid. (From the Greek words meaning "the likeness, a crow.") Resembling a crow's beak.

Cornicula Laryngis. Little horn of the larynx, cartilage of larynx Santorini, named after the man who described it first, Santorini.

Cornua. (From the Latin word cornu, "a horn.") A name applied to any excrescence resembling a horn.

Coronal. (From the Latin word corona, "a crown.") Encircling like a crown, pertaining to the crown of the head.

Coronoid. Resembling a crown.

Corporeal. (From the Latin word corporeus, from corpus, "a body.") Having a body. Pertaining to the body. C. circulation: of the body.

Corpus Callosum. (From the Latin word corpus, "a body;" callosus, from callus, "callous or hard-skinned.") The callous body. The broad band of white matter connecting the two hemispheres of the cerebrum.

Corpuscle. (Dim. of corpus, "a body.") A small body.

Corpus Hemorrhagicum. The hemorrhagic body, formed when the bloodvessels of the Graafian follicle rupture after the escape of the ovum.

Corrugator Supercilii (muscle). The wrinkler of the eyebrow.

Cortex. (From the Latin word cortex, "bark.") The bark of a tree, hence the outer covering, as the cortex cerebri, covering of the cerebrum; cortex renalis, covering of the kidney; The outer portion of an organ is called the cortex.

Costa (pl. æ). (From the Latin word costa, "a rib.") The rib.

Costal. Pertaining to the rib.

Cranium. (From the Greek word meaning cranium). The bony cavity that contains the brain, its membranes and vessels.

Cribriform. (From the Latin word cribrum, "a sieve;" forma, "form.") Perforated like a sieve.

Cricoid. Ring-shaped.

Cricothyroid. Pertaining to the cricoid and thyroid cartilages.

Crista (Galli). (From the Latin word crista, "crest.") The crista galli; cock's crest.

Crucial. (From the Latin word crux, "a cross.") Resembling a cross.

Crura Cerebri. (The legs of the cerebrum.) The peduncles of the cerebrum which connect it with the pons Crura cerebelli; any one of the cerebellar peduncles.

Crus (pl. crura). (From the Latin word crus, "a leg, support.")

Cubic Centimeter (c.c.). Is the unit of measurement used in the metric system for fluids in place of the gram; one cubic centimeter representing 1 fluid gram.

Cuboid. Resembling a cube.

Cuboidal. Nearly like the shape of a cube.

Cuneiform. From the Latin words cuneus, "a wedge;" forma, "shape.") Wedge-shaped.

Cutaneous. (From the Latin word cutis, "skin.") Pertaining to the skin.

Cuticle. (Dim. of cutis.) The epidermis (upper layer of skin).

Cutis (skin). The derma or true skin.

Cyanotic. Referring to cyanosis (a bluish discoloration of the skin and lips from deficient oxidation of the blood, caused by local or general circulatory disturbance).

Cylindrical. Having the form of a cylinder.

Cystic. (From the Greek word meaning a pouch). Pertaining to or resembling a pouch. Pertaining to the gall-bladder.

Deciduous. (From the Latin words de, "from;" cadere, "to fall.) Falling off. The deciduous teeth; temporary or milk teeth.

Decussate. (From the Latin word decussatus, "crossed.") To intersect, to cross.

Decussation. (From the Latin word decussatio, a crossing.) An X-shape crossing, especially of symmetric parts, as of nerve fibers, nerve tracts. The chief decussations are that of the optic nerves in the chiasm, and that of the crossed pyramidal tracts in the medulla.

Defecation. The evacuation of the bowels.

Deglutition. (From the Latin word deglutitio, "a swallowing.") The act of swallowing, food, water, etc.

Deltoid (muscle). Having the shape of the Greek letter Delta, Δ; triangular.

Dendraxones. Branching in appearance, like a tree.

Dendrite. (From the Greek word meaning a tree.) Branching like a tree. The processes of a nerve cell or neurone which increases its functional surface for the conduction of nerve impulses.

Dentations. Resembling the form of a tooth, as a toothed or serrated edge.

Dentoplasm. A tooth-like arrangement of the plasma.

Depressors. (From the Latin word deprimere, "to depress.") A group of muscles which depress or lower any bone or organs by their contractions.

Depressor Alæ Nasi. Depressor of the wing of the nose.

Depressor Anguli Oris. Depressor of the angle of the mouth.

Depressor Labii Inferioris. Depressor of the lower lip.

Derma. (From the Greek word meaning the skin.) The true skin.

Dextroses. (From the Latin word dexter, "right.") A group of sugars that rotate polarized light to the right.

Dialysis. The separation of several substances from each other in solution by taking advantage of their different diffusibility through porous membranes. Those that pass through readily are termed crystalloids, those that do not colloids.

Diaphragm. (From the Greek words meaning across and wall.) The musculomembranous partition which separates the thorax from the abdomen.

Diapedesis. The passage of the blood through the unruptured vessel wall.

Diarthrosis. The connection of two bones admitting of free motion between them, as at the articulations.

Diastole. (From the Greek word meaning a drawing apart) The period of dilatation of a chamber of the heart.

Diffuse. Scattered; not limited to one tissue or spot.

Digastric (muscle). Having two bellies.

Digestion. (From the Latin word digerere, "to digest.") Those processes whereby the food taken into the alimentary canal is made capable of being absorbed and assimilated by the tissues.

Dilator Naris Anterior (muscle). Anterior dilator of the nostril.

Dilator Naris Posterior (muscle). Posterior dilator of the nostril.

Diploblast. (From the Greek words meaning double sprout.) Formed of two layers.

Diploë. (From the Greek word meaning a fold.) The cancellous bony tissue between the outer and inner tables of the skull.

Disintegration. (From the Latin words dis, "apart; "integer, the whole.") The act of breaking up or decomposing.

Distal. (From the Latin word distare, "to be at a distance.") Extreme; at the greatest distance from a central point.

Diverging. To proceed from a common point in different directions.

Dorsal. (From the Latin word dorsum, "back.") Pertaining to the back of the body or organ, etc.

Dorsalis Pedis. The back of the foot.

Dorsum. The back or posterior of the body, organ, etc. (See Dorsal.)

Duct. (From the Latin word ducere, "to lead.") A tube or channel, especially one for conveying the secretions of a gland.

Ductus Arteriosus. A short vessel in the fetus connecting the pulmonary artery with the aorta.

Ductus Communicus Choledochus. The common bile duct. (Literally, the duct which receives the bile.) The common excretory duct of the liver and gall-bladder.

Ductus Venosus. A branch of the umbilical vein in the fetus which empties directly into the ascending vena cava.

Duodenum. (From the Latin word duodeni, "twelve each." So called because it is about twelve finger-breadths in length.) The first part of the small intestine .

Dura Mater. (From the Latin words dura, "hard;" mater, "mother.") The fibrous membrane forming the outer covering of the brain and spinal cord.

Ectoderm. (From the Greek words meaning outside, the skin.) The outer of the two primitive layers of the blastodermic vesicle in the embryo.

Edema. Is a swelling of the subcutaneous tissues of the body due to an abnormal or excessive transudation of the fluid portion of the blood into or its abnormal retention in the lymph spaces.

Efferent. (From the Latin word efferens, "carrying from.") Carrying away, as the efferent nerves conveying impulses away from the central nerve system; also bloodvessels and lymphatic vessels conveying blood and lymph respectively from the tissues.

Embryo. (From the Greek words meaning within, to swell with). The product of conception up to the fourth month.

Embryonic. Pertaining to the embryo.

Emissive. Sending out, as nerve impulses.

Enarthrosis. A ball-and-socket joint. Like the articulation of the hip and femur.

Encephalon. (From the Greek word meaning brain.) Brain.

Endo. A prefix meaning within.

Endocardium. (Within the heart.) The serous membrane lining the interior of the heart.

Endolymph. The fluid within the membranous labyrinth of the ear.

Endomysium. (Within a muscle.) The connective tissue between the fibrils of a muscle bundle.

Endoneurium. (Within a nerve.) The delicate connective tissue holding together the fibrils of a bundle of nerves.

Endosteum. (Within the bone.) The vascular membranous layer of connective tissue lining the medullary cavity of long bones.

Endothelial (cells). Flat cells found on the inner surface of vessels and spaces that do not communicate with the external air.

Endothelium. (From the Greek words meaning within, the nipple.) See Endothelial (cell).

Entoderm. (From the Greek words meaning within, skin). The inner of the two layers of cells in the blastodermic vesicles of the embryo.

Enzyme. Any ferment formed within the living organism.

Ependymal. Relating to the ependyma—the lining membrane of the cerebral ventricles and of the central canal of the spinal cord.

Epiblast. Same as ectoderm. (See ectoderm.)

Epicranial. Relating to epicranium; the structures covering the cranium.

Epidermis. (From the Greek words meaning upon, the skin.) The outer or superficial layer of the skin.

Epigastric. Relating to the epigastrium.

Epigastrium. (From the Greek words meaning upon, the stomach.) The upper and middle part of the abdominal surface, corresponding to the location of the stomach.

Epimysium. (Upon a muscle.) The sheath of areolar tissue surrounding a muscle.

Epineurium. (Upon a nerve.) The connective-tissue sheath of a nerve trunk.

Epiphysis. (From the Greek words meaning upon, to grow.) A process of bone attached for a time to another bone by cartilage, but soon becoming consolidated with the principal bone.

Epitendinium. (Upon a tendon.) The connective-tissue sheath of a tendon.

Epithelial. (From the Greek words meaning upon, a nipple.) Pertaining to epithelium.

Epithelium. (Upon a nipple.) The group of cells that forms the epidermis (outer skin), that lines all membranes of canals that communicate with the external air, and that are specialized for secretion in certain glands, as the liver, kidney, etc.

Equilibrium. (From the Latin words æquus "equal;" libra, "balance.") A state of balance.

Erythrocyte. A red-blood corpuscle (a small body).

Esophagus or Œsophagus. (From the Greek words meaning to carry, to eat.) The gullet. The musculomembranous canal, about 9 inches long, extending from the pharynx to the cardiac end of the stomach.

Ethmoid (bone). (From the Greek words meaning a sieve, likeness.) Sieve-like.

Excretion. (From the Latin word excernere, "to excrete.") The discharge of waste products or excretions resulting from metabolism, by the skin, kidneys, etc.

Extension. (From the Latin word extendere, "to stretch out.") A straightening out, especially the muscular movements by which a limb or joint is extended.

Extensors. (A group of muscles which straighten or extend a limb or part of the body.

Extensor Brevis Digitorum. The short extensor of the toes (digits).

Extensor Brevis Pollicis. The short extensor of the thumb.

Extensor Carpi Radialis Longior and Brevior. The long extensor of the radial side of the wrist and the short extensor of the same side.

Extensor Carpi Ulnaris. The extensor of the ulnar side of the wrist.

Extensor Communis Digitorum. The common extensor of the fingers (digits).

Extensor Indicis Proprius. The extensor of the index finger.

Extensor Longus Digitorum. The long extensor of the fingers (digits).

Extensor Longus Hallucis. The long extensor of the big toe (hallux).

Extensor Longus Pollicis. The long extensor of the thumb.

Extensor Minimi Digiti. The extensor of the little finger (digit.)

Extensor Ossis Metacarpi Pollicis. The extensor of the metacarpal bone of the thumb.

Extrinsic. (From the Latin word extrinsicus, "from without.") External, not directly belonging to a part.

Facet. (From the French word facette, "a little face.") A small plane or smooth surface on a bone, usually referring to the articular facet.

Falces (pl.) **Cerebri et Cerebelli.** The sickle-shaped processes of dura mater between the cerebrum and cerebellum, respectively.

Falciform. (From the Latin words falx, "a sickle;" forma, "form.") Having the shape of a sickle.

Falx, falcis (Latin). A sickle.

Fascia. (From the Latin word fascia, "a band.") The areolar tissue forming the layers beneath the skin, which forms sheaths for muscles and vessels.

Fascia Lata. (Broad fascia.) The fascia of the thigh.

Fasciculus. (Dim. of the Latin word fascis, a bundle.") A little bundle; as of muscle fibers.

Fauces. (From the Latin word fauces, "a throat.") The space at the back of the mouth communicating with the pharynx, surrounded by the soft palate and uvula and tonsils.

Fauces (isthmus of). The opening at the back of the mouth leading into the pharynx, bounded on the sides by the arches of the soft palate, the uvula above, the base of the tongue below.

Fecundation. (From the Latin word fecundus, "fruitful.") The act of making fruitful; impregnation; as the spermatozoön (male) fecundates the ovum (female).

Femoral. Pertaining to the femur, as arteries, veins, and muscles.

Femur. (From the Latin word femur, "thigh bone.")

Fenestra Ovalis. (From the Latin words fenestra, "a window;" ovalis, "egg-shaped," from ovum, "an egg.") The oval window

located in the vestibule of the internal ear; which communicates with the middle ear or tympanum closed in life by the stapes, an ossicle of the ear. (See Ossicle.)

Ferment. (From the Latin word fermentum, "leaven, yeast.") Any substance which in contact with another substance is capable of setting up changes—called fermentation—in the latter, without itself undergoing much change. Ferments are classified into unorganized or soluble, and organized, or living ferments.

Fermentation. The decomposition of complex molecules of chemical bodies or substances under the influence of ferments—called enzymes.

Fetus. (From the Latin word fetus, "offspring"). The unborn offspring of vivaparous (producing young in a living state) animals in the later stage of development.

Fibrocartilage. Cartilage with fibrous tissue intermixed.

Fibrous (From the Latin word fibra, "a fiber.") Containing fibers; of the character of fibrous tissue.

Fibula. (Latin, "a buckle.") The bone on the outer side of the leg.

Fibular. Pertaining to the fibula.

Filium Terminale. A long, slender thread of nerve fibers enclosed by the dura mater, practically the termination of the spinal cord.

Fimbriæ (pl. of fimbria). (From the Latin word fimbria, "a fringe"). A fringe. The fimbriæ of the Fallopian tube; the fringe-like processes of the outer extremity of the tube.

Fimbriated. Fringed.

Flexion. (From the Latin word flecture, "to bend.") The act of bending, especially the muscular movements by which a limb or joint is bent.

Flexors. A group of muscles which bend a limb or part of the body. The opposite of the extensors.

Flexor Brevis Digitorum. The short flexor of the toes.

Flexor Brevis Hallucis. The short flexor of the big toe.

Flexor Brevis Minimi Digiti. The flexor of the little finger and toe.

Flexor Brevis Pollicis. The short flexor of the thumb.

Flexor Carpi Radialis. The flexor of the radial side of the wrist.

Flexor Carpi Ulnaris. The flexor of the ulnar side of the wrist.

Flexor Longus Digitorum. The long flexor of the toes.

Flexor Longus Hallucis. The long flexor of the big toe. (See Hallux.)

Flexor Longus Pollicis. The long flexor of the thumb. (See Pollicis.)

Flexor Profundus Digitorum. The deep flexor of the fingers.

Flexor Sublimis Digitorum. The superficial flexor of the fingers.

Follicle. (From the Latin word folliculus, a dim. of follis, "bellows.") Arranged in the form of a little sac, as the lymph, hair follicles, etc.

Fontanelle. (From the Latin word fontanella, "a little fountain.") A membranous space between the angles of junction of the sutures of the cranial bones in fetal life and infancy.

Foramen Magnum. The great opening. In occipital bone.

Foramen Ovalis. The oval opening. In the wall between the auricles of the heart in the fetus, and for ten days to two weeks it persists in infant hearts.

Foramen Rotundum. The round opening. In sphenoid bone.

Foramina or **Foramen.** (From the Latin word forare, to pierce.) An opening or perforation, especially a bone.

Fossa (pl. æ). (Latin, fossa, "a ditch.") A depression or ditch.

Fossa Ovalis. The oval ditch.

Fovea. (From the Latin, "a small ditch.") A small depression.

Funiculus. (Dim. of the Latin word funis, "a rope or cord.") A cord-like structure.

Fuse. (From the Latin word fundere, "to pour out.") To unite with.

Fusiform. (From the Latin words fusus, "a spindle;" forma, "shape.") Spindle-shape.

Galactophorous. Milk-bearing.

Ganglion or Ganglia. (From the Greek word meaning a knot.) A well-defined group of nerve cells and fibers forming an underlying nerve centre.

Gastric. (From the Greek word meaning stomach.) Pertaining to the stomach.

Gastrocnemius. A double-head muscle forming with the soleus the calf of the leg.

Genitals (Genitalia). (From the Latin word genitalis, "pertaining to generation," from gignere, "to beget.") Relating to the organs of generation or reproduction in the male or female.

Genito-urinary. Relating to the genitalia and urinary organs.

Germinal. (From the Latin word germen, "a germ.") Pertaining to the development of a tissue or organ.

Gestation. (From the Latin word gestare, "to bear.") Pregnancy.

Glenoid. Resembling a shallow cavity.

Glia (cells). (From the Greek word meaning glue.) The cells found in the neuroglia (the tissue which forms the basis of the supporting frame-work of the nerve tissue of the cerebrospinal system).

Globule. (From the dim. of the Latin word globus, "a ball.") A small spheric body, as fat globules, etc.

Glomerulus. (From the Latin word glomerulus, "a little ball.") A small, rounded mass, as the coil of bloodvessels projecting into the expanded end of each uriniferous tubule and with it forming the Malpighian body or corpuscle.

Glottis, idis (Rima). The space between the vocal cords.

Gluteus. (From the Greek word meaning buttock.) Referring to muscles of the buttock.

Gluteus Maximus. The greatest of the buttock. (Literal translation.)

Gluteus Medius. The medium-sized of the buttock.

Gluteus Minimus. The smallest of the buttock

Glycogen. A carbohydrate found in the liver cells. It is stored in the liver, where it is converted, as the system requires, into sugar (glucose).

Gramme (gm.). The unit of the measurement by weight of the metric system of weights and measures. 1 gm. = 15.432 grains.

Granular. (From the Latin word granula, "a little grain.") Pertaining to granule. As the granular appearance of a cell.

Granule. (From the Latin word granula, "a small grain.") A small body or grain, as the granules of a cell.

Gustatory (nerve). (From the Latin word gustare, "to taste.") Pertaining to the sense of taste, as the gustatory nerve—the nerve of taste in the tongue.

Gyrus (pl. gyri or gyre). A convolution of the brain.

Hallux, Hallucis. From the Latin. The great toe.

Hemoglobin. The coloring matter of the red cells of the blood.

Hepar. From the Greek word meaning liver.

Hepatic. Pertaining to the liver, as hepatic artery, hepatic duct, and hepatic vein.

Hiatus (Fallopii). (From the Latin word hiare, "to gape.") A space or opening. Hiatus Fallopii: A shallow grove on the petrous portion of the temporal bone for the passage of a nerve, etc.

Hilum. A pit, recess, or opening in an organ, usually for the entrance and exit of vessels or ducts, as the hilum of the kidney, spleen, etc.

Histology. The minute or microscopic anatomy of the tissues.

Homogeneous. Having a uniform appearance or character in all its parts or substance.

Humerus (bone). (From the Latin, "arm.") The long bone of the arm extending from the shoulder to the elbow.

Hyaline. Resembling glass.

Hymen. The portion of mucous membrane which partially occludes the opening of the vagina.

Hyoid (bone). (Having the form of the Greek letter upsilon Υ.) A bone situated between the root of the tongue and the larynx, supporting the tongue and giving attachment to some of the muscles of the tongue, pharynx, and floor of the mouth.

Hyperemic. Pertaining to the excessive blood in a part (hyperemia).

Hypochondriac. Pertaining to the hypochondrium.

Hypochondrium. The upper lateral surface of the abdomen and thorax corresponding to the lower ribs.

Hypogastrium. The lower anterior surface of the abdomen above the pubes.

Hypothenar. The fleshy eminence on the palm of the hand over the metacarpal bone of the little finger.

Ileum. (From the Greek word meaning to roll.) The lower portion of the small intestine ending in the cecum.

Iliopectineal. (From the Latin words ilium, "flank;" pectens, "comb.") The line pertaining conjointly to the ilium and os pubis (bones).

Iliotibial (band). (From the Latin words ilium, "flank;" tibia, "tibia.") The thickened portion of the fascia lata of the thigh which extends from the ilium to the tibia.

Ilium (bone). Latin, "the flank.") The superior expanded portion of the innominate bone.

Impregnation. (From the Latin word impregnare, "to impregnate.") The act of rendering pregnant; fecundation.

Inferior Obliquus Oculi (muscle). The inferior oblique of the eye-ball.

Infundibulum. (From the Latin word infundere, "to pour into.") A funnel-shaped passage or part.

Inguinal. (From inguen, "the groin.") Pertaining to the groin.

Inhibitor (nerve). (From the Latin inhibere, "to check.") To check or hold back. Inhibitor nerve: One which has a controlling influence upon a nerve conveying impulses to certain organs and tissues of the body.

Innominate. (From the Latin words in, "without;" nomen, "a name.") Unnamed, unnamable; as innominate bone or artery, due to its not resembling any known object.

Inorganic. Not organic; not produced by animal or vegetable organisms, as an inorganic compound.

Insalivation. (From the Latin words in, "in;" saliva, "the spittle.") The act of mixing the food with saliva when chewed (mastication).

Inter. (From the Latin word inter, "between.") Between any structures.

Interarticular. Between joints.

Interauricular. Between the auricles of the heart.

Intercellular. Between the cells.

Intercondylar. Between the condyles, as the intercondylar notch of the femur bone.

Intercostal. Between the ribs, as intercostal muscles, arteries, nerves, and spaces.

Interlobular. Between the lobules of the liver, referring to interlobular veins and arteries.

Intermuscular (septa). Between muscles.

Interosseous. Between bones.

Intertrochanteric (line). Between the trochanters of femur.

Interventricular. Between the ventricles of the heart.

Intralobular. (From the Latin words intra, "within;" lobulus, "a little lobe.") Within a lobule, as an intralobular vein of liver.

Intrinsic. (From the Latin word **intrinsecus,** "on the inside.") Inherent, situated within; peculiar to a part, as the intrinsic muscles of the eye.

Involuntary. (From the Latin words in, "not;" velle, "to will.") Performed or acting independently of the will, as involuntary muscle.

Ischium. The bone forming the back and lower part of the innominate bone.

Jejunum. (From the Latin word jejenus, "empty;" because it is usually found empty after death.) The second portion of the small intestine extending between the duodenum and ileum and measuring about eight feet in length.

Katabolism. Physiologic disintegration of the products of metabolism. The opposite of anabolism. (See Anabolism.)

Kinetic (energy). (From the Greek word meaning to move.) Producing motion.

Labyrinth. (From the Greek word meaning a maze.) The name given to the series of cavities of the internal ear comprising the vestibule, cochlea, and semicircular canals.

Lacrimal. (From the Latin word lacrima, "a tear.") Pertaining to the tears, or the organs containing or secreting them.

Lactation. (From the Latin word lactere, "to suckle.") The period during which the child is nourished from the breast.

Lacteal. (From the Latin word lac, "milk.") Resembling milk. Any one of the lymphatic ducts of the villi of the small intestine which take up the chyle; the chyle resembling milk as to color.

Lacuna (pl. æ). (From the Latin word lacus, "a lake.") A lake, as the lacunæ of bone construction.

Lamella (pl. æ). (Dim. of the Latin word lamina, "a plate.") A thin scale or plate.

Lamina (pl. æ). Latin. A plate.
Lamina Spiralis. A spiral plate.
Larynx. The organ of voice situated between the base of the tongue and the trachea.
Lateral. (From the Latin word latus, "the side.") At, belonging to, or pertaining to the side. Situated on either side of the middle vertical plane.
Latissimus Dorsi (muscle). The widest of the back.
Levator Anguli Oris. The elevator of the angle of the mouth.
Levator Labii Superioris Alæque Nasi. The elevator of the upper lip and the wing of the nose.
Levator Menti. The elevator of the chin.
Levator Palati. The elevator of the palate.
Levator Palpebræ Superioris. The elevator of the upper eyelid.
Leukocyte. A white-blood cell or corpuscle, seen in the blood; microscopic.
Ligamentum Patellæ. The ligament of the patella (knee-cap bone).
Linea Alba. White line.
Linea Aspera. Rough line on the posterior aspect of the femur.
Linea Semilunaris. (From the Latin words linea, "a line;" semilunaris, from semi, "half;" luna, "a moon.") The line resembling a half moon in shape.
Linea Transversa. The transverse line.
Liter. (From the Latin word litra, "a pound.") The unit of capacity in the metric system. One liter equals 1.76 pints.
Lobule. (From the Latin word lobulus, dim. of lobus, "a lobe.") A small lobe.
Locomotion. (From the Latin words locus, "a place;" motio, "motion," from movere, "to move.") The act of moving from place to place, as in walking, etc.
Lumbar. (From the Latin word lumbus, "a loin.") Pertaining to the loins or lower part of back.
Lymphocyte. A lymph cell. Belonging to the group of white cells. Seen in the blood; microscopic.
Lymphoid. Having the appearance or character of lymph.
Major Calices. The larger calices (see Calices).
Malar. (From the Latin word mala, "cheek.") Pertaining to the cheek bone. The bone of the prominence of the cheek.
Malleolus. (Dim. of the Latin word malleus, "a hammer.") A part or process of bone having a hammer-head shape. As the malleolus of the tibia and fibula.
Mandible. (From the Latin word mandere, "to chew.") The jaw bone.
Mastication. (From the Latin word masticare, "to chew.") The act of chewing.
Mastoid. (Resembling the shape of a nipple.) Pertaining to the mastoid process.
Maxilla (jaw bone). The bone of the upper or lower jaw.
Maximus. The greatest.
Meatus. (From the Latin word, meare, "to flow or pass.") An opening or passage. Auditory meatus, etc.
Medius. The middle.

Medulla. The marrow. Anything resembling marrow, as the medulla oblongata. Also the central part of an organ.

Medullated. Containing or covered by a substance resembling medulla or marrow. Medullated nerves covered with a myelin sheath.

Mediastinum. (From the Latin words in, medio, stare, "to stand in the middle.") The space in the middle of the chest between the two pleuræ, divided into anterior, middle, posterior, and superior mediastinum.

Membrane. (From the Latin word membrana, from membrum, "a member.") A thin layer of tissue lining or surrounding a part or separating adjacent cavities.

Mesentery. A fold of peritoneum which connects the intestine with the posterior abdominal wall.

Meshes. Net-work, reticular.

Mesocolon. The fold of peritoneum connecting the colon with the posterior abdominal wall.

Mesoderm. The middle layer of the blastodermic vesicle of the embryo, derived from both the ecto- and entoderm.

Mesogastrium or Umbilical. The region corresponding to the part of the abdominal wall surrounding the umbilicus (navel).

Metabolism. The group of phenomena occurring in the tissues whereby the organic beings transform foodstuffs into complex tissue elements (anabolism), and convert complex substances into simple ones in the production of energy (katabolism).

Metacarpal. Relating to the metacarpus.

Metacarpus. (From the Greek words meaning beyond the wrist.) That part of the hand between the bones of the wrist and the bones of the fingers.

Metatarsal. Pertaining to the metatarsus.

Metatarsus. (From the Greek words meaning beyond the instep.) That part of the foot between the bones of the instep and the bones of the toes.

Micturition. (From the Latin word micturire, "to pass water.") The act of passing urine.

Millimeter (mm.). The thousandth part of a meter. Equal to 0.039370 inch.

Minimus. The least, smallest.

Minor. The lesser, smaller.

Minor Calices. The smaller calices.

Mitral (bicuspid). (Resembling a miter, a covering for the head worn by popes, bishops, and cardinals.) The valves of the left auriculo-ventricular opening of the heart.

Molecular. (From the Latin word mole, "a mass"). Pertaining to or composed of molecules.

Molecule. (From the Latin word, a dim. of moles, "mass.") The minute portion of matter. In physics the smallest quantity into which a substance can be divided and retain its characteristic properties; or the smallest quantity of any gas, liquid, or solid that can exist in a free state.

Motor. (From the Latin word movere, "to move.") Moving or causing motion. Concerned or pertaining to motion, as motor cells, motor nerves, motor centre.

Mucous. Containing or having the nature of mucous.

Multipolar. (From the Latin words multus, many; polus, "a pole.") Having many poles, as multipolar nerve cells, having many processes.

Myelinic. Relating to myelinic nerve fibers, those possessing a myelin sheath.

Myocardium. The muscular tissue of the heart.

Myosin. (From the Greek word meaning muscle.) A protein of the globulin class, found in coagulated muscle-plasma, and formed from the antecedent globulin myosinogen.

Naris (pl. es). (From the Latin word naris, "the nostril.") One of a pair of openings at the anterior or posterior part respectively of the nose.

Nasal. (From the Latin word nasus, "the nose.") Pertaining to the nose.

Nervus Intermedius. The nerve situated between, as the Nervus intermedius between the facial and auditory nerves.

Neural (canal). Pertaining to nerves. Neural canal: The bony canal comprising the cavity of the cranium and vertebral column which contains the central nerve system.

Neurilemma. The sheath encasing a nerve fiber.

Neuroglia. The tissue forming the basis of the supporting framework of the nerve tissue. It consists of glia cells.

Neurone or Nerve Cell. One of the countless number of units of which the nerve system is composed. The basis for all nerve tissue activity.

Node. (From the Latin word nodus, "a swelling.") A knob, swelling, or protuberance.

Nodule. (Nodulus, dim. of nodus, "a swelling.") A small node or swelling.

Nucha (pl. æ). (Ligamentum nuchæ.) (From the Latin word nucha, "nape of neck.") The ligament of the nape of the neck.

Nucleated. Possessing a nucleus.

Nucleolus. (Dim. of nucleus from nux, "a nut.") The small rounded body within the cell nucleus.

Nucleus. (From the Latin word nux, "a nut.") The essential part of a typical cell, usually round in outline, and situated near the centre.

Nutrient Canal. One that affords nourishment, as the nutrient canal of a bone, which contains a nutrient artery.

Obturator. (From the Latin word obturare, "to stop up.") That which closes an opening; as obturator membrane or foramen of innominate bone.

Occipital (bone). Pertaining to the occiput. (See Occiput.)

Occipitofrontalis (muscle). From the occiput to the forehead.

Occiput. (From the Latin words ob, "against;" caput, "the head.") The back part of the head.

Odontoid. Resembling a tooth.

Olecranon (process). The large convex portion of the back part of the upper end of the ulna. The point of the elbow felt beneath the skin.

Olfactory. (From the Latin word olfacere, "to smell.") Pertaining to the sense of smell.

Omentum. Any fold of peritoneum attaching an organ to the stomach. The greater omentum overlies the small intestines like an apron.

Opponens. (From the Latin words ob, "against;" ponere, "to place.") Opposing.

Opponens Minimi Digiti (muscle). The muscle which places the little finger opposite to the thumb.

Opponens Pollicis (muscle). The muscle which places the thumb opposite to the little finger.

Optic Chiasm. (See Chiasm.)

Orbicularis Oris (muscle). From the Latin word orbiculus, a dim. of orbis, "a circle.") The circular one of the mouth.

Orbicularis Palpebrarum (muscle). The circular one of the eyelids.

Orbit. (From the Latin word orbita, from orbis, "a circle.") The bony pyramidal cavity containing the eye and its muscles, etc.

Orbital. Pertaining to the orbit.

Organic. (From the Greek word meaning an organ.) Having or pertaining to, or characterized by organs; relating to the animal and vegetable worlds; affecting the structure of organs.

Orifice. (From the Latin words orificium; os, "a mouth;" facere, "to make.") An opening or outlet of hollow organs, or between organs.

Os Innominata (bone) (pl. ossa innominatæ). (From the Latin os, "a bone;" innominata, in, "without;" nomen, "a name.") The nameless bone, due to its not resembling any known object.

Os Magnum. (The great bone.) The third bone of the second row of carpal bones (bones of the wrist).

Osmosis. (The passage of liquids and substances in solution through porous septa (a partition).

Osseocartilaginous. Formed of, or pertaining to bone and cartilage as one.

Ossicle. (From the Latin word ossiculum, a dim. of os, "a bone.") A small bone. Auditory ossicles or chain of small bones found in the middle ear. They are the incus, stapes, and malleus.

Ossification. From the Latin words os, "a bone;" facere, "to make.") The process of bone formation.

Osteoblasts. Cells concerned in the formation of bony tissue during ossification.

Osteoclasts. The multinuclear (many nuclei) cells found against the surface of bone in little eroded depressions (Howship's fovea), and concerned in the removal of bone.

Ostium Uterinum or Uteri. The mouth of the uterus (womb).

Ovum. (From the Latin word ovum, "an egg.") The reproductive cell of an animal or vegetable, an egg.

Oxidation. (From the Greek word meaning sharp.) The act or process of combining with oxygen, as the hemoglobin of the red cells does during respiration, and the cells of the tissues combine with it as the hemoglobin of the red cells in the blood gives it up upon reaching them. Oxidation is essential to body metabolism.

Oxygen. Is a colorless, tasteless, odorless gas, one of the non-metallic elements. It constitutes one-fifth of the atmosphere, eight-ninths of water, three-fourths of organized bodies, and about one-half

the crust of the globe. It is essential to combustion or burning with the elimination of heat and light when oxidation takes place. It is not a food, but is essential to the act of respiration. Its absence causes asphyxia or suffocation.

Palate. The roof of the mouth.

Palmaris Brevis (muscle). The short one of the palm.

Palmaris Longus (muscle). The long one of the palm.

Palpebral. Pertaining to the eyelid.

Papilla (pl. æ). (From the Latin papilla, "a nipple.") A small nipple-like eminence.

Parietal. (From the Latin word paries, "a wall.") Forming or pertaining to the wall of a cavity, or portion of a membrane attached to it, as parietal peritoneum, etc.

Pars Intermedius. The part between, referring to the nervus intermedius.) (See N. intermedius.)

Parturition. (From the Latin word parturitio, from partuire, "to bring forth.") The act of giving birth to the young.

Patella (bone). (From the Latin word a dim. of patera, "a shallow dish.") The knee-pan, or knee-cap; a round small bone in front of the knee, developed in the tendon of the quadriceps extensor muscle.

Pectoral. (From the Latin word pectus, "a breast.") Pertaining to the chest.

Pectoralis Major (muscle). The larger one of the chest.

Pectoralis Minor (muscle). The smaller one of the chest.

Pedicle. (From the Latin word pediculus, dim. of pes, pedis, "a foot.") A slender process acting as a foot or stem.

Peduncle. (From pedunculus, a dim. of pes, "a foot.") A narrow part acting as a support.

Pelvic. Pertaining to the pelvis.

Pelvis. (From the Latin word pelvis, "a basin.") A basin-shaped cavity. The bony ring formed by the two innominate bones and the sacrum and coccyx.

Peptone. The final protein body or substance formed by the action of ferments on albumins during gastric and pancreatic digestion.

Peri. A Greek prefix signifying around.

Pericardium. (Around the heart.) The serous membrane surrounding the heart.

Perichondrium. The fibrous connective tissue surrounding the surface of cartilage.

Perimysium. (Around a muscle.) The connective tissue surrounding the primary bundles of muscle fibers.

Perineum. That portion of the body corresponding to the structures overlying the outlet of the pelvis.

Periosteum. (Around bone.) A fibrous membrane investing the surface of bones.

Peripheral. Pertaining to or placed near the periphery.

Periphery. (From the Greek words meaning around, to carry.) The circumference; the external surface, or extreme portions of the body or an organ.

Peristalsis. A peculiar wave-like movement seen in tubes provided with longitudinal, transverse, and oblique muscle fibers, as the intestinal canal, stomach, etc.

Peristaltic. Pertaining to peristalsis.

Peritendineum. (Around a tendon.) The fibrous sheath investing the small bundles of tendon fibers.

Peritoneum. (From the Greek words meaning around, to stretch.) The serous membrane lining the interior of the abdominal cavity and surrounding the contained viscera. It forms folds for the support of organs called ligaments (of liver, uterus, etc.); attaches organs to each other, as **omentum** when another organ is connected to the stomach, thus gastrosplenic omentum; as the intestines are held to the posterior abdominal wall: thus the **mesentery;** as the colon is attached to the wall of the abdomen: thus the **mesocolon.** The organs behind the peritoneum are spoken of as **retroperitoneal organs.**

Peroneal. Pertaining to the fibulă bone. The region overlying the fibula.

Peroneus Brevis (muscle). The short peroneal.

Peroneus Longus (muscle). The long peroneal.

Pes Anserinus. (From the Latin word pes, "a foot;" anserinus, "a goose"). A goose foot; named, as the branches of the facial nerve are supposed to spread like the toes of a goose foot.

Petrous. (From Greek word meaning rock, stony, of the hardness of stone.)

Phalanx (pl. phalanges). One of the bones of the fingers or toes.

Pharynx. (From the Greek word meaning throat). The musculo-membranous tube situated back of the nose, mouth, and larynx.

Phrenic. Pertaining to the diaphragm or diaphragmatic region, surface, etc.

Pia Mater. (From the Latin words pia, "tender;" mater, "mother.") The tender mother. The vascular membrane enveloping the surface of the brain and spinal cord.

Pigment. (From the Latin word pingere, "to paint.") A coloring matter, or dye-stuff. Pigments may be in solution or in the form of granules or crystals; as the pigment of skin in negroes, etc.; iris of eye.

Pisiform (bone). (From the Latin words pisum, "a pea;" forma, "form.") Pea-shaped. A bone of the wrist.

Placenta. (From the Greek word meaning a cake.) The organ on the wall of the uterus to which the embryo is attached by means of the umbilical cord and from which it receives its nourishment and excretes the waste products from about the third month of gestation to the birth of the child (parturition). It is called the "after-birth" by the laity.

Placental. Referring to the placenta.

Plantar. (From the Latin word planta, "the sole of the foot.") Referring to the sole of the foot.

Plasma. The fluid part of the blood and lymph.

Platysma Myoides (muscle). The broad muscle (from the Greek).

Pleura. (From the Greek word meaning a rib.) The serous membrane covering the lungs and inner surface of the wall of the thoracic cavity.

Pollicis. (From the Latin word pollen, pollicis, "the thumb.") Of the thumb.

Polygonal. Having many angles.

Polyhedral. Having many sides.

Potential (energy). (From the Latin word potens, "able.") Capable of acting or doing work.

Poupart's Ligament. The ligament extending from the anterior superior spine of the iliac bone to the spine of the pubic bone. It is the lower border of the aponeurosis of the external oblique muscle of the abdomen.

Pretracheal. In front of the trachea.

Prevertebral. In front of the vertebral column.

Proligerous (disk). (From the Lätin word proles, "offspring;" gere, "to bear.") Producing offspring. The layer of cells in the membrana granulosa of the Graafian follicle that surrounds the ovum.

Pronation. (From the Latin word pronare, "to bend forward.") The act of turning the palm downward; the opposite of supination.

Pronator Quadratus (muscle). Square pronator. See pronation.

Pronator Radii Teres (muscle). The round pronator of the radius.

Protein or Proteid. Any one of the important and essential constituents of animal and vegetable tissues containing nitrogen.

Proteolysis. The change produced in proteins or proteids by ferments that convert them into diffusible bodies.

Proteolytic Ferments. Pertaining to those ferments which are characterized or effect proteolysis.

Proteose. Any one of a group of bodies formed in gastric digestion intermediate between the food proteins and peptones, called antipeptones, hemipeptones.

Protoplasm. The viscid material constituting the essential substance of living cells, upon which all the vital functions of nutrition, secretion, growth, reproduction, irritability, motility depend.

Proximal. (From the Latin word proximus, "the nearest.") Nearest to the body, or the median line of the body. Proximal phalanx: The nearest bone of the finger.

Proximate (principles). (From the Latin word proximus, "nearest.") Nearest. Proximate principles, substances which can exist under their own form in the animal solids or fluids, and that can be extracted by means not altering or destroying their chemic properties.

Pterygoid. Wing-shaped.

Puberty. From the Latin word pubertas, from puber, "adult.") The period at which the generative organs become active in both sexes, and become capable of reproduction.

Pubes. The hairy region covering the os pubis (pubic bone).

Pubic. Pertaining to the pubes.

Pubis (Os). The bone of the pubes. The lower and anterior part of the innominate bone.

Pyloric. Pertaining to the pylorus of the stomach, as pyloric artery, vein, etc.

Pylorus. (From the Greek word meaning gate-keeper.) The circular opening of the stomach into the duodenum.

Pyramidal. Shaped like a pyramid.

Pyramidalis (muscle). The muscle shaped like a pyramid found at the lower part and inserted into the linea alba of the abdominal wall. There are two.

Pyramidalis Nasi (muscle). The pyramidal one of the nose.

Quadratus. Squared; four-sided.

Quadrangular. Having four angles.

Quadriceps (extensor tendon). The four-headed extensor tendon.

Racemose. (From the Latin word racemus, "a bunch of grapes.") Resembling a bunch of grapes.

Radius (bone). (From the Latin word radius, "the spoke of a wheel.") The outer bone of the forearm.

Rami Communicantes. (From the Latin words ramus (pl. i), "a branch;" communicans (pl. antes), "communicating.") Communicating branches. The branches of a spinal nerve connecting it with the sympathetic ganglia.

Reflex (action). (From the Latin words re, "back;" flectere, "to bend.") Anything bended or thrown back. Reflex act: An act following immediately upon a stimulus without the intervention of the will.

Refractory (apparatus). (From the Latin words re, "back;" frangere, "to break.") Literally, to break the natural course of, as rays of light; to cause them to deviate from a direct course, as the refractory apparatus of the eye deviates the rays of light as to how they shall fall upon the retina (diffuse or concentrated), based upon the nearness or distance of an object to or from the eye.

Renal. (From the Latin word ren, "a kidney.") Pertaining to the kidney.

Renalis (fascia). Fascia of the kidney.

Renes (pl. of ren.). The kidneys.

Reniform. Kidney-shaped.

Reticular. (From the Latin word reticulum, dim. of rete, "a net.") Resembling a net, formed by a net-work, as reticular tissue.

Reticulum. A net-work.

Retiform. Having the form of a net.

Rhythmical. Pertaining to rhythm. In speaking of the heart and pulse it refers to the dividing of their actions (contraction and relaxation) into short portions or periods by a regular succession of motions.

Rima Glottidis. The chink of the glottis. The cleft or narrow opening between the true vocal cords in the larynx.

Risorius (muscle). (From the Latin word ridere, "to laugh.") The laughing muscle.

Rotation. (From the Latin words rotare, "to turn;" from rota, "a wheel.") The act of turning about an axis, passing through the centre of a body or extremity.

Rugae. (Plural of ruga, "a fold or ridge.") Folds.

Saccharoses. (From the Greek word meaning sugar.) A group of carbohydrates occurring in the juice of many plants, chiefly sugar-cane, some varieties of maple and beet-sugar.

Sacrum (bone). (From the Latin word sacer, "sacred;" os, understood.)

Sagittal. (From the Latin word sagitta, "an arrow.") Arrow-like, as the sagittal suture of the skull. Referring to the anteroposterior middle plane of the body, or organ, etc.

Saphenous. Apparent, superficial; applied to the saphenous vein of the thigh and leg, lying just beneath the skin and superficial fascia.

Sarcolemma. The delicate membrane enveloping a muscle fiber.

Sarcoplasm. The finely granular material between the fibrils of muscle tissue.

Sartorius (muscle). (From the Latin word sartor, "a tailor.") The tailor muscle. Named after the ancient method the tailor assumed while at work, squatting with his knees bent, and the feet and leg crossed.

Scaphoid (bone). Boat-shaped. A bone of the wrist and instep.

Scapula (bone). (From the Latin.) A shoulder-blade.

Secretion. (From the Latin word secernere, "to secrete, separate.") 1. The act of secreting or forming from materials furnished by the blood a certain substance which is either eliminated by the body or is used in carrying on certain functions. 2. The substance secreted, as bile, sweat, etc.

Secretor or Secretory. Pertaining to or performing secretion of a gland, etc.

Sella Turcica. (A Turkish saddle.) The pituitary fossa of the body of the sphenoid bone, lodging the pituitary body.

Semilunar. (From the Latin words semi, "half;" luna, "moon.") Resembling a half-moon in shape.

Semimembranosus (muscle). Half-membrane.

Semitendinosus (muscle). Half-tendon.

Septum (pl. septa). (From the Latin word sepire, "to hem in.") A partition, a dividing wall, as nasal septum, etc.

Sensor or Sensory. (From the Latin word sentire, "to feel.") Pertaining to or conveying sensation, as a sensor nerve.

Serous (membrane). Pertaining to or resembling serum.

Serum. (From the Latin word serum, "serum.") 1. The clear, yellowish fluid separating from the blood after the coagulation of the fibrin. 2. Any clear fluid resembling the serum of the blood.

Sigmoid. Shaped like the Greek letter Σ.

Sinus. A hollow or cavity.

Soleus (muscle). A flat muscle of the calf.

Solitary. (From the Latin word solitarius, "solitary.") Single, existing separately.

Specific Gravity. The measured weight of a substance compared with that of an equal volume of another taken as a standard.

Sphenoid. Wedge-shaped.

Spheric. Having the shape of a sphere.

Sphincter. A muscle surrounding and closing an orifice; as sphincter ani muscle.

Spicule. A minute, sharp-pointed body, as a spicule of bone.

Spinal (nerve). 1. Pertaining to the spine. 2. Pertaining to the spinal cord.

Spinus. (From the Latin word spina, "a spine or thorn.") Resembling or pertaining to a spine.

Squamous. (From the Latin word squamosis, "scaly.") Of the shape of a scale.

Stellate. (From the Latin word stella, "a star.") Star-shaped.

Sternohyoid (muscle). From the sternum to the hyoid bone.

Sternomastoid (muscle). From the sternum to the mastoid.

Sternothyroid (muscle). From the sternum to the thyroid cartilage.

Sternum. Breast bone.

Stratified. (From the Latin word stratum, "a layer;" facere, "to make.") Formed into a layer or layers.

Stratum Germinatum. The sprouting layer (skin).

Stratum Grànulosum. The granular layer (skin).

Stratum Lucidum. The clear layer (skin).

Stratum Mucosum. The mucous layer (skin).

Striated. Striped.

Stroma. The tissue forming the frame-work for the necessary part of an organ or tissue.

Stylohyoid. Pertaining to the styloid process of the temporal bone and the hyoid bone.

Styloid. Resembling a pillar.

Sub. A prefix denoting under or beneath.

Subaponeurotic. Beneath the aponeurosis.

Subclavian. Beneath the clavicle.

Subclavius (muscle). Beneath the clavicle.

Subcostal. Beneath a rib.

Subcutaneous. Beneath the skin.

Subendothelial. Beneath the endothelium. (See endothelium.)

Subpubic. Beneath the symphysis pubes.

Sulcus. A furrow or groove. (From the Latin)

Sulcus Pulmonalis. The groove of the lung.

Superciliary. (From the Latin words super, "above;" cilium, "an eyelash.) Pertaining to the eyebrow.

Supination. (From the Latin word supinus, "on the back.") The act of turning the palm of the hand upward. The condition of being on the back. Opposite of pronation.

Supinator Brevis (muscle). The short supinator (assists to turn the palm upward).

Supinator Lòngus (muscle). The long supinator (assists to turn the palm upward).

Supracondylar. Above the condyle.

Suprapatellar. Above the patella.

Suprarenal. Above the kidney.

Sutural. (From the Latin word sutura, "a suture;" from sutere, "to sew or stitch.") Pertaining to suture.

Suture. A suture. The seam or joint which unites the bones of the skull.

Symphysis (pubes). The line of junction of two bones Symphysis pubis: The line of junction of the two bodies of the pubic bones located at the front of the true pelvis.

Synarthrosis. A form of joint or articulation in which the bones are firmly bound together and are immovable. They have no synovial membrane.

Synchondrosis. A joint in which the surfaces of bones are connected by a cartilage.

Syndesmosis. A form of joint in which the bones are held together by ligaments.

Synovia. The clear, alkaline, lubricating fluid secreted by the cells of a synovial membrane, found within a synovial sac.

Synovial. Pertaining to the synovia.

Systole. (From the Greek words together, to place.) The contraction of the heart muscle. Auricular systole, the contraction of the auricle of the heart; ventricular systole, the contraction of the ventricle of the heart.

Tactile. (From the Latin word tactus, from tangere, "to touch.") Pertaining to the sense of touch.

Tarsus. The instep.

Temporal (bone). (From the Latin word tempus, "time (temple).") Pertaining to the temple, as temporal bone, artery, etc.

Tendo Achillis. The tendon of Achilles. (Tendon, from the Latin word tendere, "to stretch.") The common tendon of the gastrocnemius and soleus muscles.

Tendo Oculi. The tendon of the eyeball.

Tensor Vaginæ or Fasciæ Femoris. The stretcher of the sheath (fascia lata) of the thigh.

Tentorium Cerebelli. The tent of the cerebellum. The partition of dura mater between the cerebrum and cerebellum.

Thenar. (From the Greek word meaning palm.) 1. The palm of the hand. 2. The fleshy prominence of the palm corresponding to the base of the thumb; also called thenar eminence (ball of the thumb).

Thermal. Pertaining to heat.

Thermic. Pertaining to heat.

Thoracic. Pertaining to or situated in the thorax or chest.

Thorax. From the Greek word meaning chest.

Thyrohyoid (muscle). From the thyroid cartilage to the hyoid bone, as thyrohyoid muscle and membrane.

Thyroid. Shield-shaped. Pertaining to the thyroid gland, cartilage, etc.

Tibia (bone). (From the Latin word tibia, "a shin.") The large bone on the inner side of the leg.

Tibiofibular (articulation). Pertaining to the tibia and fibula.

Tissue. (From the Latin word texere, "to weave.") An arrangement of similar cells and fibers, forming a distinct structure, and entering as such into the formation of an organ or organism.

Tonicity. The condition of normal tone or tension of organs; a state of tone.

Tonus. The normal state of tension of a part or of the body.

Trabecula (pl. æ). (From the Latin word trabecula, "a small beam.") Any one of the fibrous bands extending from the capsule into the interior of an organ.

Trachea. Windpipe.

Transitional. Denoting a change from one shape to another.

Trapezium (bone). (Named after the resemblance it bears to a trapezium; shaped like an irregular four-sided figure.) The first bone of the second row of the wrist.

Trapezius (muscle). Resembles a trapezium in shape.

Trapezoid (bone). Resembles a trapezoid—a four-sided geometric figure having two parallel and two diverging sides.

Triceps (muscle). Three-headed.

Tricuspid. Having three cusps or points.

Trochanters. The processes on the upper extremity of the femur.

Trochlear. Pertaining to or having the nature of a pulley.

Trophic. (From the Greek word meaning nourishment.) Pertaining to nutrition. Trophic centre, a collection of ganglion cells regulating the nutrition of a nerve, and thus through the latter the part it supplies.

Tuber Cinereum. A tract of gray matter at the base of the cerebrum, extending from the optic chiasm to the corpora mammillaria, and forming part of the floor of the third ventricle.

Tuberculum or Tubercle. (From the Latin word tuberculum, "a tubercle.") A small nodule. A rounded prominence on a bone.

Tuberosity. (From the Latin word tuber, "a swelling.") A protuberance on a bone.

Tubular. From the Latin word tubulus, a dim. of tubus, "a tube.") Shaped like a tube. Pertaining to a tube.

Tubule. From the Latin word tubulus, "a small tube."

Tunica. (From the Latin word tunica, "tunic.") A coat or membrane.

Tunica Adventitia. The outer coat of an artery or vein.

Tunica Intima. The inner coat of an artery or vein.

Tunica Media. The middle coat of an artery or vein.

Tympanic (membrane). Pertaining to the tympanum.

Tympanum. (From the Greek word meaning "a drum.") The middle ear.

Ulna (bone). (From the Latin word ulna, "a cubit.") The bone on the inner side of the forearm.

Unciform (bone). (From the Latin word uncus, "a hook;" forma, "form.") Hook-shaped. A hook-shaped bone in the second row of the wrist.

Unipolar. (From the Latin words unus, "one;" polus, "a pole.") Having but one pole or process. As a unipolar nerve cell.

Urea. The chief nitrogenous constituent of the urine, and principal end-product of tissue metabolism.

Uriniferous (tubules). (From the Latin words urina, "urine;" ferre, "to bear.") The tubules which carry or convey urine from the kidney substance to the pyramids of the kidney.

Uvula. (From the Latin word uvula, from the dim. of uva, "a grape.") The cone-shaped appendage hanging from the free edge of the soft palate.

Vagina. (From the Latin word vagina, "a sheath.") 1. A sheath. 2. The musculomembranous canal extending from the vulval opening to the mouth of the cervix of the uterus (ostium externum), ensheathing the latter and the penis (male) during coitus. (See Coitus.)

Vaginal. 1. Pertaining to or of the nature of a sheath. 2. Relating to the vagina.

Valvulæ Conniventes. The small transverse folds of mucous membrane of the small intestine.

Vasa Brevia. The short vessels. The small branches of the splenic artery which pass to the fundus of the stomach.

Vasoconstrictor (nerves). (From the Latin words vas, "vessel;" constringere, "to constrict.") Nerves which when stimulated cause a contraction of the bloodvessels.

Vasodilator. (From the Latin words vas, "a vessel;" dilator, "a dilator.") Nerves which when stimulated cause a dilatation of the bloodvessels.

Vasomotor. (From the Latin words vas, "a vessel;" motor, from movere, "to move." Regulating the tension of the bloodvessels.

Venæ Cavæ. (Literally, the hollow veins.) The two large veins that open into the right auricle of the heart.

Venæ Comites. (Accompanying veins.) Veins that accompany an artery in its course.

Venæ Cordis Minimi. The smallest veins of the heart.

Ventral. (From the Latin word venter, "belly.") Pertaining to the belly. Or used in meaning in front, as ventral aspect.

Ventricle. A small cavity or pouch. (From the Latin ventriculus, a dim. of venter, "a belly.")

Venule. A small vein.

Vermiform (appendix). (From the Latin word vermis, "a worm;" forma, "form.") Worm-shaped appendix.

Vernix Caseosa. (A cheesy varnish.) The sebaceous deposit covering the surface of the fetus. Seen on delivery.

Vertebra. (From the Latin word vertere, "to turn." A single bone of the spinal column.

Vertebral. Referring to or characteristic of the vertebra.

Vertex. (That which turns or revolves about itself, from the Latin word vertere, "to turn.") The crown or top of the head or skull.

Vesica Urinaris. The urinary bladder.

Villus (pl. villi). (From the Latin word, "a tuft of hair.") The minute club-shaped projections from the mucous membrane of the small intestine, consisting of a lacteal vessel, an arteriole, and a venule, enclosed in a layer of epithelial cells.

Virgin. A woman who has never had sexual intercourse.

Viscera Plural of viscus, meaning the organs of the abdomen, etc.

Visceral. Relating to viscera, the stomach, liver, etc.

Vitreous (humor). (From the Latin word vitreus, from vitrum, "glass.") The transparent, jelly-like substance filling the posterior chamber of the eye.

Volatile. (From the Latin word volatilis, from volare, "to fly.") Passing into vapors at ordinary temperatures; evaporating.

Voluntary. Under the control of the will. Voluntary muscles, etc.

Vomer. (From the Latin, "a ploughshare.") The thin plate of bone situated vertically between the nasal cavities, which forms the posterior portion of the nasal septum (partition).

Vulva. (From the Latin word volvere, "to roll up.") The external organs of generation in the woman.

Zygoma. (From the Greek word meaning cheek bone.) The bony arch above the cheek and in front of the ear formed by the zygomatic processes from the temporal and malar bones.

Zygomatic. Relating to the zygoma.

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